U.S. Department of the Interior
U.S. Geological Survey

Evaluation of Nonpoint-Source Contamination, Wisconsin: Water Year 1999

Open-File Report 01–105

Prepared in cooperation with the
Wisconsin Department of Natural Resources

USGS
science for a changing world

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By J.F. Walker, D.J. Graczyk, S.R. Corsi, J.A. Wierl, and D.W. Owens

U.S. GEOLOGICAL SURVEY
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Middleton, Wisconsin
2001

science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, *Secretary*

U.S. GEOLOGICAL SURVEY
Charles G. Groat, *Director*

For additional information write to:

District Chief
U.S. Geological Survey
8505 Research Way
Middleton, WI 53562-3586

Copies of this report can be purchased from:

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225-0286

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To Obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
acre	0.4048	hectare
square mile (mi^2)	2.590	square kilometer
million cubic feet (Mft^3)	0.02832	million cubic meters
pound (lb)	453.6	gram
pounds per square mile (lb/mi^2)	0.17573	kilograms per square kilometer (kg/km^2)
ton (short)	0.9072	megagram (Mg)

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by use of the following equation:

°F = 1.8 (°C) + 32.

Abbreviated water-quality units used in this report: Chemical concentrations and water temperature are given in metric units. Chemical concentration is given in milligrams per liter (mg/L), micrograms per liter (µg/L). Milligrams per liter is a unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter. For concentrations less than 7,000 mg/L, the numerical value is the same as for concentrations in parts per million.

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Abstract

The objective of the watershed-management evaluation monitoring program in Wisconsin is to evaluate the effectiveness of best-management practices (BMPs) for controlling nonpoint-source pollution in rural and urban watersheds. This progress report provides a summary of the data collected by the U.S Geological Survey for the program and a discussion of the results from several different detailed analyses conducted within this program.

A land-use and best-management-practice inventory is ongoing for each evaluation monitoring project to track the different sources of nonpoint-source pollution in each watershed and to document implementation of best-management programs that may cause changes in the water quality of streams. Updated information is gathered each year, mapped, and stored in a geographic-information-system database. Summaries of BMP-implementation data collected through the 1999 water year are presented in this report.

Suspended sediment and total phosphorus storm-load and annual-load data are summarized for eight rural sites. For all 8 rural sites a sufficient number of pre-BMP storm samples have been collected; for two of the sites (Brewery and Garfoot Creeks), a sufficient number of post-BMP storm samples have been collected to allow for a final assessment of the effectiveness of the BMPs. For the remaining sites, numerous transitional storm samples have been collected, but in all cases BMP implementation has lagged such that there are insufficient post-BMP storm samples for final analysis. For two sites (Rattlesnake and Kuenster Creeks) there are not enough planned BMPs to warrant further data collection.

Continuous dissolved-oxygen data collected at 5 rural sites are summarized. In terms of instantaneous concentrations when comparing pre-BMP data to transitional and post-BMP data, the general trend is a reduction in the number of days that the dissolved oxygen concentration was less than the state standard. These results are anecdotal, however; the differences have not been rigorously tested statistically. For a level of dissolved oxygen sustained over a continuous hour, the results are mixed. In general the number of days with standard violations has decreased, but there are notable exceptions.

For the four urban streams, the pre-BMP data were examined to determine the level of improvement that could potentially be detected with a statistical analysis. Regression analyses were performed relating constituent loads of suspended solids, total phosphorus and total copper to various independent variables, including seasonal terms and variables related to rainfall. On the basis of the residuals from the regressions, there is a wide range of potential change that could be detected with an analysis of pre- and post-BMP loads. This is likely a result of the high degree of variability in the data, particularly from site to site. For suspended solids, total phosphorus, and total recoverable copper the minimum detectable changes ranges from 20–80, 30–70 and 30–90 percent, respectively.

For two of the eight rural streams (Rattlesnake and Kuenster Creeks) minimal BMP implementation has occurred, hence a comparison of pre-BMP and data collected after BMP implementation began is not warranted. For two other rural streams (Brewery and Garfoot Creeks), BMP implementation is complete. For the four remaining rural streams (Bower, Otter, Eagle, and Joos Valley Creeks), the pre-BMP load data were compared to the transitional data to determine if significant reductions in the loads have occurred as a result of the BMP implementation to date. For all sites, the actual constituent loads for suspended solids and

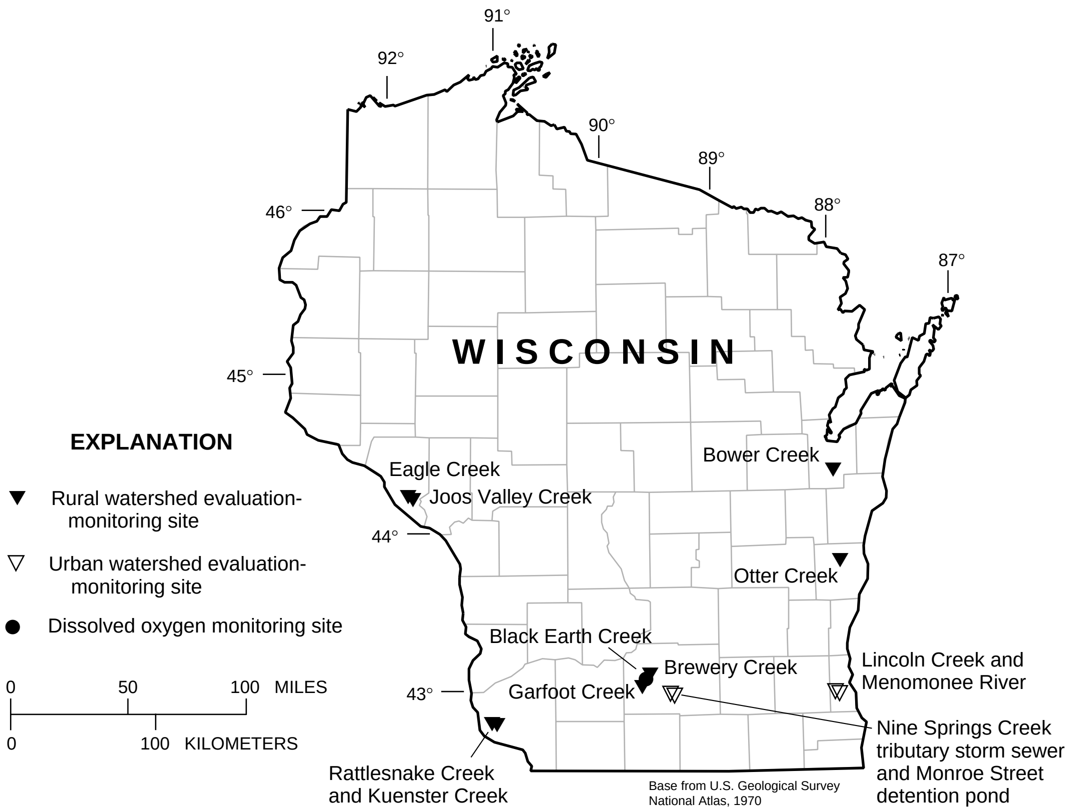

Figure 1. Locations of rural and urban sites in the Wisconsin watershed-management evaluation monitoring program.

total phosphorus exhibit no statistically significant reductions after BMP installation. Multiple regressions were used to remove some of the natural variability in the data. Based on the residual analysis, for Otter Creek, there is a significant difference in the suspended-solids regression residuals between the pre-BMP and transitional periods, indicating a potential reduction as a result of the BMP implementation after accounting for natural variability. For Joos Valley Creek, the residuals for suspended solids and total phosphorus both show a significant reduction after accounting for natural variability. It is possible that the other sites will also show statistically significant reductions in suspended solids and total phosphorus if additional BMPs are implemented.

INTRODUCTION

In October, 1989, the U.S. Geological Survey (USGS) began a watershed-management evaluation monitoring program in cooperation with the Wisconsin Department of Natural Resources (WDNR). The overall objective of each individual project in the program is to determine if the water quality of the receiving stream has improved as a result of the implementation of land-management practices in the watershed. This is accomplished through monitoring of water chemistry and ancillary variables before best-management practices (BMPs) are implemented, during implementation, and after watershed-management practices have been completely implemented. The period before BMP implementation is termed “pre-BMP,” the period during active implementation is termed “transitional,” and the period after complete implementation is termed “post-BMP.”

Eight rural and four urban sites were selected jointly by WDNR and USGS for detailed evaluation monitoring. The sites were selected using a variety of criteria, including likelihood for significant BMP implementation, relatively small watershed size [less than 50 square miles (mi^2)], feasibility for accurate stream gaging, etc. Locations of the sites are shown in figure 1.

The county Land Conservation Departments (LCDs) and the WDNR have identified nonpoint sources of pollution in each rural watershed. This information was used to select sites that are eligible for partial funding of BMP implementation. The LCDs are in the process of contacting landowners to request that they implement the appropriate BMPs for stream water-quality improvement. This is a voluntary program that may result in varied success depending largely upon the percentage of landowners that implement the recommended BMPs.

The four urban sites were selected from the watersheds identified in the Priority Watershed program. The WDNR and each city have identified nonpoint sources of pollution in the urban watersheds. Nonpoint-source pollution reduction goals have been set, but a specific plan identifying the type and location of BMPs needed to achieve these goals has not been defined.

This report, the fifth in a series of progress reports, provides a summary of data collected for the watershed-management evaluation monitoring program in Wisconsin. The following topics are addressed:
(1) land-use and BMP inventories, including a discussion of data-collection efforts and the status of BMP implementation; (2) stream water-quality data, including a discussion of data-collection efforts, a comparison of annual loads for the rural sites, and a discussion of dissolved-oxygen data collection; (3) urban load regression analysis, including a brief discussion of the statistical approach for trend detection and presentation and discussion of preliminary pre-BMP regressions for the urban sites; and (4) transitional data analysis, including regression results and a preliminary trend assessment for some of the rural sites. For sections presenting ongoing data-collection efforts, data collected during water year 1999 (October 1997 through September 1999) are summarized and, if appropriate, implications for future data-collection efforts are discussed.

LAND-USE AND BEST-MANAGEMENT PRACTICE INVENTORIES

Inventories of the eight rural watersheds began in 1992 to provide information on land-use and land-treatment changes in support of the whole-stream evaluation monitoring effort. Detailed descriptions of each watershed and the program are provided in Rappold and others (1997) and Wierl and others (1996). This section summarizes the land-use-inventory program activities through the 1999 water year and planned activities for the 2000 water year.

Activities through 1999 Water Year

Annual updates of BMP implementation status have been conducted since 1992. The tracking system is in a Geographic Information System (GIS) data base that also provides spatial layers of land use and land cover. The tracking method and details about the data base are described in Rappold and others (1997).

In 1998 the inventory team used land-use information from the Otter Creek watershed and appropriate models to estimate phosphorus loads from barnyards and cropland areas. Model parameters were determined using a farm-field characteristic layer from the GIS data base. Soils from specific sites were collected for particle-size analysis using the method described in Dong and others (1979). A detailed description of the model results and methods for locating significant sources of phosphorus, which could be used to target resources, is reported in Wierl and others (1998).

In 1999 Brewery and Garfoot Creek watersheds completed the post-BMP period achieving the majority of the goals set by the WDNR and the local Land Conservation Department (table 1). Additional practices may be implemented in the next several years but the majority of sources were controlled by the practices already implemented. Land-use tracking was discontinued in 1999 because the post-monitoring phase was considered completed.

Tracking of the Otter Creek, Bower Creek, Eagle Creek, and Joos Valley Creek watersheds will continue until the post-monitoring phases have been completed (table 1). Rattlesnake Creek and Kuenster Creek have not been tracked for several years because of lack of BMP implementation and discontinuation of WDNR funding for BMP implementation.

Activities Planned for Water Year 2000

The following land-use and BMP monitoring activities are planned for water year 2000:

1. Complete an inventory of agricultural crops being grown in each watershed;

2. Complete an inventory of BMPs implemented in each watershed; and

3. Assess if watersheds are going into the post-monitoring phase.

Table 1. Summary of eligible, contracted, and implemented rural best-management practices in nonpoint-source evaluation monitoring watersheds, Wisconsin

[ft, feet; BMPs, best-management practices; table contains revisions to a BMP table previously published in Rappold and others (1997), which are the result of changes in practices eligible, contracted, or implemented. Data are numbers of sites unless otherwise noted.]

Practice	Evaluation monitoring watershed: Brewery Creek	Garfoot Creek	Eagle Creek and Joos Valley Creek	Bower Creek	Otter Creek	Rattlesnake Creek and Kuenster Creek
Animal-waste management						
Eligible manure storage	0	0	7	7	4	[1]60
Contracted manure storage	0	0	[2]3(1)	[3]5(2)	4	2
Implemented manure storage	0	0	1	5 (17 others from previous farm programs	3	1
Eligible barnyard-control systems	20	7	18	20	7	90
Contracted barnyard-control systems	[2,3]16(5)	[2]6(1)	[2]8(4)	13	7	[2]5(1)
Implemented barnyard-control systems	10	6	2	12	6	10
Streambank protection						
Eligible streambank protection[4]	22,000 ft	16,800 ft	28,100 ft	2,320 ft	7,000 ft	[1]255,000 ft
Contracted streambank protection[4]	22,000 ft	16,800 ft	8,275 ft	970 ft	2,000 ft	1,730 ft
Implemented streambank protection[5]	19,100 ft	16,700 ft	320 ft	970 ft	2,000 ft	1,605 ft
Contracted fencing	1,200 ft	5,475 ft	25,165 ft	625 ft	9,200 ft	0
Implemented fencing	Site no longer with livestock	5,475 ft	3,130 ft	625 ft	9,200 ft	0
Contracted stream crossing	1	4	9	1	3	2
Implemented stream crossing	1	4	4	1	3	2
Contracted grade stabilization	2	2	10	10.2 acres	4	0
Implemented grade stabilization	Sites no longer with livestock	2	7	10.2 acres	4	0
Upland management						
Eligible nutrient management	2,440 acres	590 acres	990 acres	4,020 acres	1,130 acres	[1]2,980 acres
Contracted nutrient management	1,415 acres	155 acres	555 acres	1,940 acres	1,575 acres	[1]275 acres
Implemented nutrient management	1,415 acres	155 acres	230 acres	1,940 acres	1,575 acres	[1]275 acres
Eligible upland BMPs[5]	[1]5,170 acres	[1]1,520 acres	[1]2,140 acres	4,480 acres	851 acres	[1]17,400 acres
Contracted upland BMPs[6]	1,145 acres	285 acres	30 acres	1,350 acres	14 acres	700 acres
Implemented upland BMPs[6]	1,145 acres	285 acres	30 acres	1,350 acres	14 acres	50 acres

[1]An estimate derived from the nonpoint-source control plan.

[2]Total includes a barnyard-control system installed by landowner without cost-share funding.

[3]Number of yards without livestock, which could be from farm's situation, or farm was sold. For Garfoot Creek one system was installed but livestock is now sold.

[4]The contract for length of streambank protection reflects the total length of each practice. One eroded site can include several practices such as riprap, shoreline and streambank stabilization, and shoreline buffers. Both banks may have been eroded, contracted, or implemented with BMPs.

[5]Includes an individual practice or series of practices, other than nutrient management, that result in a reduced pollutant source, such as contour farming, contour strip cropping, field strip cropping, grassed waterways, and reduced tillage.

SELECTED STREAM-WATER QUALITY DATA

Stream-water quality data are summarized in three parts in this section. The first part discusses the availability of water-quality data, including loads for stormflow periods. The second part discusses specific data compiled at rural sites, and includes (1) a graph of the number of storms and estimated constituent loads, and (2) annual constituent loads for the specific period of record at each site. The third part discusses dissolved-oxygen data collection at the rural watershed evaluation sites.

Availability of Stream-Water Quality Data

Precipitation, streamflow volume, and storm loads for several water-quality constituents have been computed for all monitored storm periods and summarized for rural sites (appendix). The rural data are summarized through water year 1998. Data collection was suspended on July 1, 1996 for four of the rural sites (Eagle, Joos Valley, Rattlesnake and Kuenster Creeks) pending continued implementation of the watershed plans. Accordingly, data in the appendix are complete through the end of the appropriate data-collection period for these four sites. Daily loads for selected constituents and discrete concentration data for the samples used to calculate these loads are published in the USGS annual water-data reports for Wisconsin (Holmstrom and others, 1986–87; Holmstrom and Erickson, 1989; Holmstrom and others, 1990–98). Maximum, minimum, and mean dissolved-oxygen concentrations and water temperatures also are published in these annual reports. All data collected at the evaluation-monitoring sites are available by request from the USGS office in Middleton, Wisconsin.

In addition to the data published in various reports, electronic retrievals of the data are possible through the world-wide-web. Historical streamflow data is available by connecting to the following uniform resource locator (URL):

http://water.usgs.gov/nwis-w/WI/index.cgi

Instantaneous constituent concentrations as well as storm-period data (precipitation, streamflow volume, and constituent loads) are available through the District Office.

Summary of Loads at Rural Stream Sites

Water-quality monitoring at the eight rural evaluation monitoring sites (fig. 1) continued at selected sites with sampling during baseflow and stormflow periods. Instantaneous water-quality data were used in conjunction with continuous streamflow data to estimate total constituent loads for stormflow periods. Suspended sediment or suspended solids, total phosphorus, and ammonia-nitrogen loads were computed at the eight rural evaluation monitoring sites. For Brewery and Garfoot Creeks, suspended-sediment loads were computed in a manner consistent with pre-BMP data collected in a previous study; for all other sites, suspended-solids loads were computed. Ammonia-nitrogen loads were not computed for sites on Otter and Bower Creeks. The rural storm-load data will be used to evaluate the effect of BMPs on stream-water quality. Previous research using the rural regression analysis (Walker and Graczyk, 1993; Walker, 1994) has shown theoretically that the minimum detectable change at rural sites reaches a minimum at roughly 40 total storms; this corresponds to 20 pre-BMP and 20 post-BMP storms for a balanced data collection. The number of pre-BMP, transitional, and post-BMP storms for which loads were calculated at rural evaluation monitoring sites for the period of record ending in the 1998 water year is shown in figure 2.

The pre-implementation, transitional, and post implementation periods have been selected for all eight rural evaluation monitoring sites (table 2). Loads for a sufficient number of storms are available for the pre-BMP implementation period at all of the eight rural evaluation monitoring watersheds (fig. 2). At two of the watersheds (Brewery and Garfoot Creeks), storm data has been collected during the post-BMP implementation period (fig. 2). For the period April 1, 1997 through September 30, 1998, loads have been calculated for 17 post-BMP storms at Garfoot Creek, which will be compared to the storm loads calculated during the pre-implementation period. For the period October 1, 1996 through September 30, 1998, loads have been calculated for 19 post-BMP storms at Brewery Creek, which will be compared to the storm loads computed during the pre-implementation period. Data collection at Bower, Eagle, Joos Valley, Rattlesnake, and Kuenster Creeks has been suspended. At Eagle and Joos Valley Creeks, the sign-up period has been extended so it was prudent to suspend monitoring until a sufficient number of BMPs have been installed. Implementation of BMPs

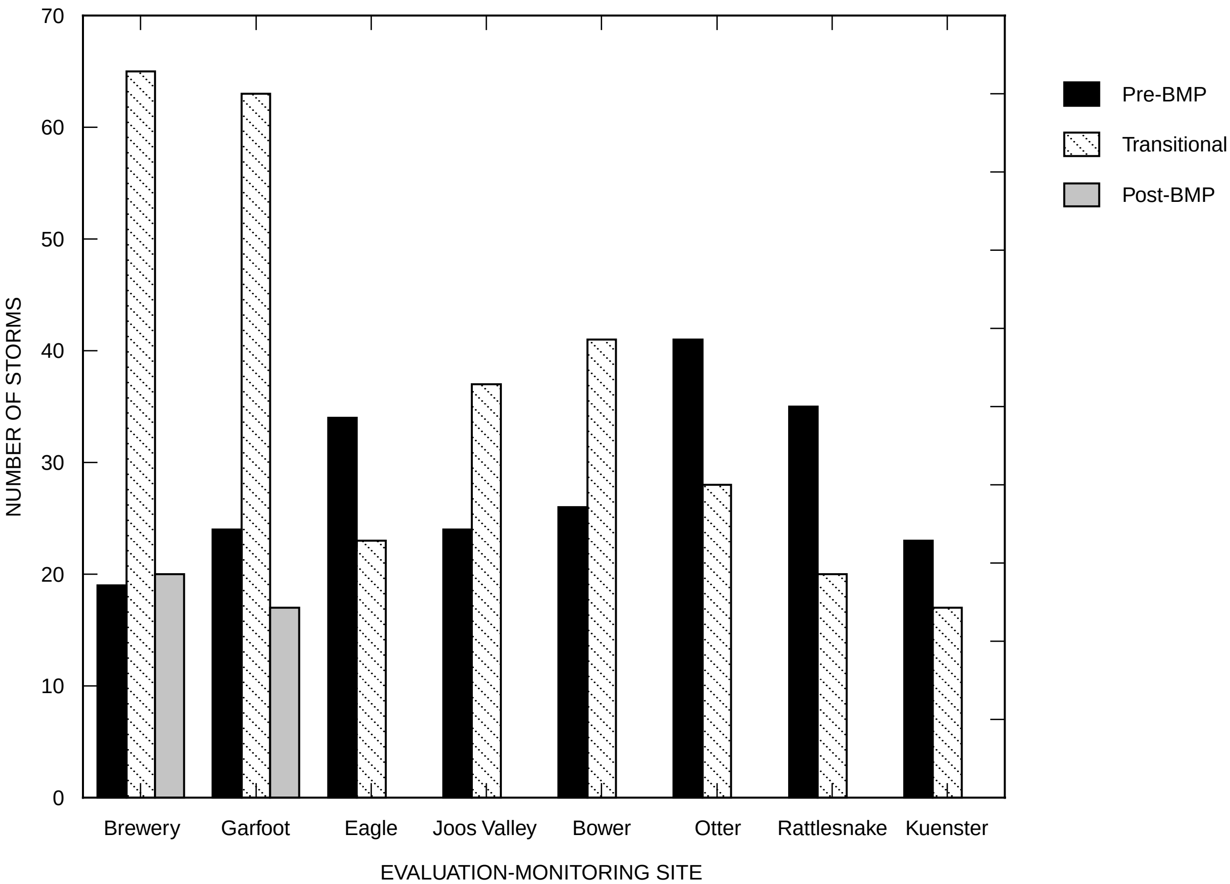

Figure 2. Number of storms through water year 1998 for which loads were calculated at the evaluation-monitoring sites. (Storms are tabulated for the period before implementation of best-management practices (pre-BMP), during installation (transitional) and after completion of BMP installation (post-BMP).)

in Eagle and Joos Valley Creeks will not be completed until the year 2000 or after (table 2). In Rattlesnake and Kuenster Creeks, the post-BMP implementation began in 1996 and 1998 respectively (table 2). At this time very few landowners in these two basins have participated in the cost-sharing program. With few landowners participating and not many BMPs installed, the chances of observing a statistically detectable change in water quality will be slight. Monitoring will begin again if sufficient BMPs have been installed. At all four of these sites there has been a sufficient number of samples taken during pre-BMP storms and additional pre-BMP storm samples are not needed.

Annual loads of suspended sediment or suspended solids and total phosphorus were determined at each of the eight rural evaluation monitoring sites (fig. 1) for the period of data collection through the 1996 water year. The annual loads are summarized in table 3. For the four sites that had complete data collection in water year 1996 (Garfoot, Brewery, Otter, and Kuenster Creeks) the suspended sediment or solids and total phosphorus load were less than the mean for the data collection period (table 3). The suspended solids and total phosphorus loads at Otter Creek were the lowest for the 5-year data-collection period (table 3). The total streamflow for water year 1996 was also the lowest during this period, which may account for the low constituent loads in water year 1996 rather than an improvement in water quality that may have resulted from BMP implementation.

Dissolved Oxygen

Dissolved-oxygen data were collected continuously at five rural sites: Garfoot Creek, Black Earth Creek at South Valley Road, Otter Creek, Rattlesnake Creek, and Kuenster Creek (fig. 1). Dissolved oxygen data were collected during open water periods; all dissolved-oxygen meters were removed during the winter.

Table 2. Pre-implementation, transitional, and post-implementation periods for the rural evaluation monitoring watersheds

Rural evaluation monitoring watersheds	Pre-BMP implementation period	Transitional period	Post-BMP implementation period
Brewery Creek	Prior to 10/31/89	11/01/89 to 07/30/96	After 09/30/96
Garfoot Creek	Prior to 09/30/90	10/01/90 to 03/31/97	After 04/01/97
Eagle Creek	Prior to 09/30/93	10/01/93 to 09/30/00	After 10/01/00
Joos Valley Creek	Prior to 09/30/92	10/01/92 to 09/30/00	After 10/01/00
Otter Creek	Prior to 09/30/93	10/01/93 to 09/30/97	After 10/01/97
Bower Creek	Prior to 11/30/92	12/01/92 to 09/30/99	After 10/01/99
Rattlesnake Creek	Prior to 05/31/93	06/01/93 to 09/30/96	After 10/01/96
Kuenster Creek	Prior to 06/30/94	07/01/94 to 09/30/98	After 10/01/98

It is difficult to determine if the water quality as measured by dissolved-oxygen concentration has improved. Because dissolved-oxygen concentration in the stream is a function of other factors such as atmospheric pressure and water temperature, any changes in minimum dissolved-oxygen concentration may be a result of these atmospheric inputs rather than implementation of best-management practices.

Maximum, minimum, and mean concentrations of dissolved oxygen for each of the five rural sites for water years 1990–96 are listed in table 4. The maximum dissolved oxygen was 20.0 mg/L at Otter Creek in water year 1996 (table 4). The minimum dissolved oxygen was 0.00 mg/L at Rattlesnake Creek in water year 1991. The three warm-water streams (Rattlesnake, Kuenster and Otter Creeks) had minimum dissolved-oxygen concentrations less than 1.0 mg/L. Dissolved-oxygen concentrations below 1.0 mg/L for extended periods of time are lethal to fish and other aquatic organisms. At the two cold-water streams (Garfoot and Black Earth Creek) the minimum dissolved oxygen was not less than 1.0 mg/L (table 4). The minimum dissolved oxygen concentration at Garfoot Creek was 1.3 mg/L in water year 1992. The minimum dissolved-oxygen concentration at Black Earth Creek was 3.9 mg/L in water year 1991 (table 4).

The State of Wisconsin has different water quality standards for dissolved oxygen based on stream water temperatures. For warm-water streams with maximum water temperature above 24.0° Centigrade (C) the minimum dissolved-oxygen concentration required is 5.0 milligrams per liter (mg/L) (Wisconsin Administrative Code, 1992). For cold-water streams with a maximum water temperature below 24.0°C, the minimum dissolved-oxygen concentration required is 6.0 mg/L (Wisconsin Administrative Code, 1992). The number of days the dissolved-oxygen concentrations were less than these standards and the total number of days dissolved-oxygen concentrations were monitored during water year 1990–96 are listed in table 5. At Garfoot Creek the number of days dissolved-oxygen concentrations were less than 6.0 mg/L decreased in 1992 through water year 1994 (table 5). The number of days that the State standard was violated at Garfoot Creek was 22 in water year 1992 but in 1994 there was only 1 day the standard was violated. During water years 1995 and 1996, the State standard was violated on 2 and 3 days, respectively. At Black Earth Creek there were no violations of the State standard in water year 1996, in contrast to water year 1995 during which there were 41 days when the minimum dissolved-oxygen concentration was less than the State standard.

At the warm-water streams, Otter Creek had 62 violations of the State standard in water year 1995 but in water year 1996 there were only 7 violations (table 5). This was the fewest violations of the State standard during the years this site has been monitored (table 5).

The return period in days and the continuous time that the dissolved-oxygen concentration is less than the State standards also may affect aquatic organisms. A frequency analysis was done to determine the return period in days when the instantaneous dissolved-oxygen concentration would be less than the State of Wisconsin standard for one hour. In 1996 at Garfoot Creek the dissolved-oxygen concentration was less than 6.0 mg/L for one continuous hour once every 21 days or about 7 times during the summer period of May through September (fig. 3). This is an improvement from water years 1990, 1992, and 1994 but not from water years 1991 and 1995 (fig. 3). In water year 1991 the dis-

Table 3. Summary of annual suspended-sediment or suspended-solids loads, total phosphorus loads, and streamflow at Wisconsin evaluation monitoring sites, water years 1985–86 and 1990–96

[--, not computed; lb, pound; mi^2, square miles; Mft^3, million cubic feet; 05406470, station number]

Water year	Suspended-sediment or suspended-solids load (tons)	Total phosphorus load (lb)	Total streamflow (Mft^3)
Brewery Creek—05406470 (contributing area 7.7 mi^2)			
1985	894	4,840	86.0
[1]1986	[a]279	[1]1,590	[1]75.0
1990	521	3,850	36.5
1991	45.3	700	18.4
1992	180	1,960	28.4
1993	2,640	10,700	135
1994	792	3,420	125
1995	525	1,390	79.6
1996	1,010	4,620	83.8
[2]Mean	[2]800	[2]3,840	[2]72.7
Garfoot Creek—05406491 (contributing area 5.39 mi^2)			
1985	462	3,060	166
[1]1986	[1]441	[1]2,450	[1]156
1990	337	2,850	100
1991	290	2,100	103
1992	200	2,230	127
1993	1,160	7,080	243
1994	238	1,720	155
1995	330	1,749	171
1996	784	3,360	175
[2]Mean	[2]431	[2]2,970	[2]152
Eagle Creek—05378185 (contributing area 14.3 mi^2)			
[1]1990	[1]4,340	[2]9,460	384.5
1991	6,580	11,600	244
1992	3,920	8,900	287
1993	7,960	17,900	425
1994	5,690	11,600	370
[1]1995	[1]5,530	[1]11,200	[1]310
1996	[1]2,380	[1]6,030	[1]228
[2]Mean	[2]6,040	[2]12,500	[2]331
Joos Valley Creek—05378183 (contributing area 5.09 mi^2)			
[a]1990	[1]1,150	3,080	[1]28.3
1991	1,470	3,160	95.6
1992	1,390	3,880	127
1993	2,900	6,440	183

Table 3. Summary of annual suspended-sediment or suspended-solids loads, total phosphorus loads, and streamflow at Wisconsin evaluation monitoring sites, water years 1985–86 and 1990–96—Continued

[--, not computed; lb, pound; mi^2, square miles; Mft^3, million cubic feet; 05406470, station number]

Water year	Suspended-sediment or suspended-solids load (tons)	Total phosphorus load (lb)	Total streamflow (Mft^3)
Joos Valley Creek—05378183 (contributing area 5.09 mi^2)—Continued			
1994	2,100	4,990	162
[1]1995	[1]6,230	10,100	[1]139
1996	[1]1,070	2,510	[1]1,120
[2]Mean	[2]1,970	4,620	[2]142
Bower Creek—04085119 (contributing area 14.8 mi^2)			
1991	718	9,480	217
1992	1,450	10,800	200
1993	11,100	26,600	584
1994	2,420	9,143	144
[1]1995	[1]0.01	[1]7.8	[1]0.60
1996	[1]1,540	[1]7,660	[1]384
[2]Mean	[2]3,920	[2]14,000	[2]286
Otter Creek—040857005 (contributing area 9.5 mi^2)			
1991	308	2,490	181
1992	285	2,180	202
1993	867	5,580	343
1994	216	3,060	193
1995	86.0	810	107
1996	180	1,990	187
Mean	352	2,820	205
Rattlesnake Creek—05413449 (contributing area 42.4 mi^2)			
1992	5,870	30,600	213
1993	35,500	156,000	427
1994	8,480	34,800	245
1995	--	--	693
Mean	16,600	73,800	395
Kuenster Creek—054134435 (contributing area 9.59 mi^2)			
1993	9,690	38,000	385
1994	3,180	9,180	199
1995	347	2,300	133
1996	[1]470	[1]4,680	[1]135
Mean	[2]4,410	[2]16,500	[2]239

[1]Partial year of the data collected.

[2]Mean does not include partial years.

Table 4. Summary of dissolved-oxygen concentration in surface water at Wisconsin watershed-management evaluation-monitoring sites, water years 1990–96

[Concentrations are in milligrams per liter;--, no data]

Water year	Maximum	Minimum	Mean	Maximum	Minimum	Mean
		Garfoot Creek			**Rattlesnake Creek**	
1990	17.4	1.5	9.4	16.7	0.05	9.2
1991	14.6	4.7	9.5	16.8	.00	9.6
1992	13.7	1.3	8.8	16.3	.09	8.8
1993	13.1	4.0	9.1	14.9	4.8	9.6
1994	12.3	4.2	9.6	17.3	4.8	9.1
1995	13.9	5.1	9.1	13.3	3.1	8.5
1996	15.2	4.5	9.8	17.5	2.5	8.7
		Black Earth Creek At South Valley Road			**Kuenster Creek**	
1990	17.1	4.8	9.6	--	--	--
1991	18.3	3.9	9.7	--	--	--
1992	18.3	4.3	9.7	19.9	.80	8.5
1993	13.5	5.2	9.2	16.2	.50	9.5
1994	16.3	5.0	9.3	19.0	2.0	8.8
1995	16.1	4.4	9.0	16.0	3.8	8.7
1996	17.1	6.5	9.9	15.3	3.5	9.0
		Otter Creek				
1990	16.0	.8	7.3			
1991	19.1	3.2	9.1			
1992	17.6	.2	9.7			
1993	16.5	3.6	8.8			
1994	16.7	3.7	8.4			
1995	17.4	2.6	7.8			
1996	20.0	4.5	9.0			

solved-oxygen concentration was less than 6.0 mg/L for one continuous hour once every 48 days or three times a summer. In 1995 the dissolved-oxygen concentration was less than 6.0 mg/L for one continuous hour once every 53 days or three times during the summer period (fig. 3). The frequency analysis may show a slight improvement in water quality based on dissolved-oxygen concentration in water years 1990, 1992, and 1994 compared to 1996. There would be no improvement in water quality if the comparison is made using water years 1991, 1993, and 1995 to 1996. It could be interpreted that the water quality has improved on the basis of the dissolved-oxygen minimum concentrations shown in table 5). The minimum dissolved-oxygen concentration was less than 2.0 mg/L in water year 1990 and 1992 but in water year 1991 and 1993 through 1996, the minimum dissolved-oxygen concentration was 4.0 mg/L or higher at Garfoot Creek (table 4). The number of days that the instantaneous minimum dissolved-oxygen concentration was less than 6.0 mg/L was one, two, and three days in the 1994 through 1996 water years, respectively. The maximum number of days the instantaneous dissolved oxygen was less than the State standard was 22 in water year 1992 (table 5).

In water year 1991, 1993 and 1994 at Otter Creek the dissolved-oxygen concentration was less than 5.0 mg/L for one continuous hour once every 10 days or about 15 times during the 153 day summer period (fig. 4). In water year 1992, the dissolved-oxygen concentration was less than 5.0 mg/L for one continuous hour once every 20 days or about 8 times during the summer period (fig. 4). In 1995, the dissolved-oxygen concentration was less than 5.0 mg/L for one continuous hour once every 3 days or about 51 times during the summer period (fig. 4). In 1996, however, the dissolved-oxygen concentration was less than 5.0 mg/L for one continuous hour once every 17 days or about nine times during the summer period. This is an improvement from water year 1995 but not from water year 1992.

As at Garfoot Creek, it may be difficult to determine if the water quality has improved as measured by

Table 5. Number of days that dissolved-oxygen concentration in surface water was less than the State of Wisconsin standard at selected stream sites during water years 1990–96

[mg/L, milligrams per liter; °C, degrees centigrade]

Water year	Number of days dissolved oxygen concentration was less than 6 mg/L	Total number of days dissolved oxygen was monitored	Number of days dissolved oxygen concentration was less than 5 mg/L	Total number of days dissolved oxygen was monitored
	Coldwater streams[1]		Warmwater streams[2]	
	Garfoot Creek		Otter Creek	
1990	12	183	14	43
1991	9	249	25	202
1992	22	169	23	206
1993	11	132	18	142
1994	1	[3]79	30	150
1995	2	118	62	159
1996	3	137	7	140
	Black Earth Creek at South Valley Road		Rattlesnake Creek	
1990	21	182	21	229
1991	49	217	14	206
1992	21	158	35	161
1993	4	157	1	156
1994	3	115	2	164
1995	41	144	9	141
1996	0	116	4	[4]59
			Kuenster Creek	
1992			53	171
1993			4	141
1994			16	133
1995			10	142
1996			5	[4]40

[1]Cold-water streams typically have maximum stream-water temperature less than 24°C.

[2]Warm-water streams typically have maximum stream-water temperature greater than 24°C.

[3]Partial year April–May and August–September.

[4]Data collection June and July only. Data collection discontinued on June 30, 1996.

dissolved-oxygen concentration at Otter Creek. The number of days that the dissolved-oxygen concentration was less than the State standard were the fewest in water year 1996 (table 5). In addition, the minimum dissolved-oxygen concentration measured was 4.5 mg/L in 1996, which is the highest minimum dissolved-oxygen since data collection began in 1990 (table 4). In the 1990 and 1992 water years the minimum dissolved-oxygen concentration was less than 1.0 but in the 1995 water year, the minimum dissolved-oxygen concentration minimum was 2.6 (table 4). The number of days the dissolved-oxygen concentration for one continuous hour was less than the State standard was fewer in water year 1996 as compared to water year 1995. Water year 1995 had the most days below the State standard for one continuous hour. Water year 1992, however, had the fewest days below 5.0 for one continuous hour. No best-management practices were implemented before the 1993 water year.

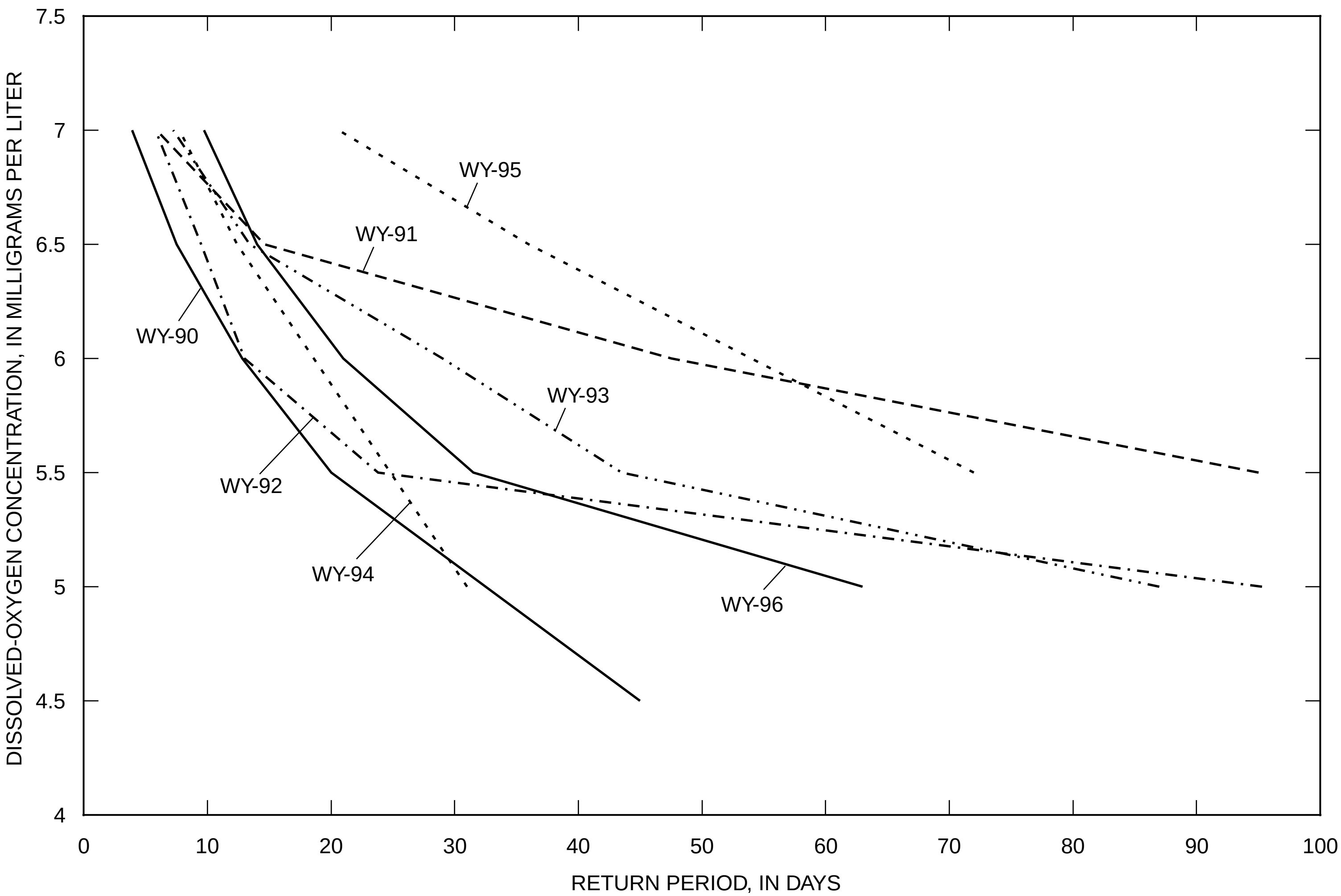

Figure 3. Return period, in days, that the dissolved-oxygen concentration was less than a given concentration for one continuous hour, May through September, for water years (WY) 1990–96 at Garfoot Creek, Wisconsin.

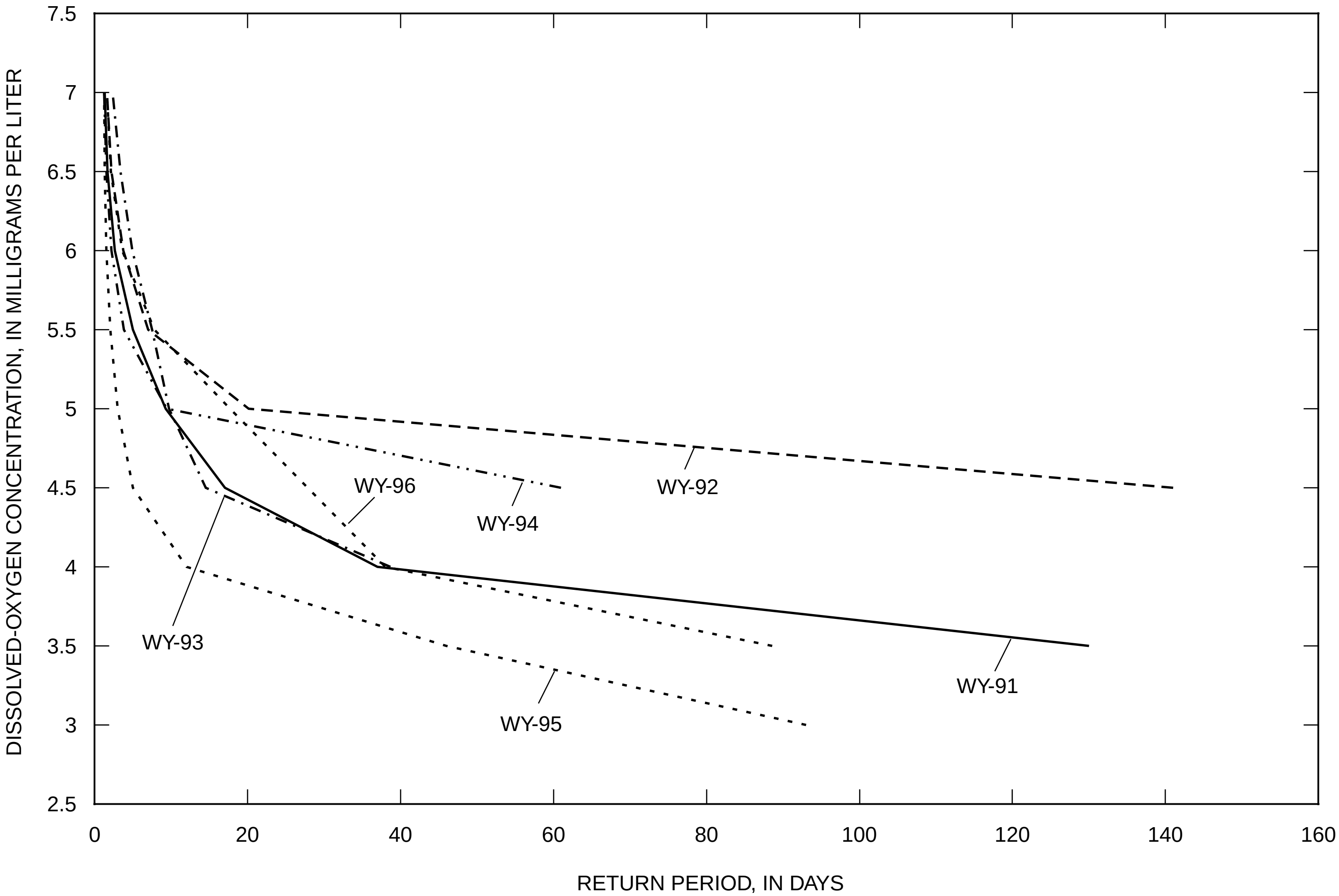

Figure 4. Return period, in days, that the dissolved-oxygen concentration was less than a given concentration for one continuous hour, May through September, for water years (WY) 1990–96 at Otter Creek, Wisconsin.

Monitoring Plan for Water Year 2000

The following water-quality-monitoring activity is planned for water year 2000:

> Continue collection of rural stormflow samples for determination of suspended-solids or suspended-sediment, total-phosphorus and ammonia-nitrogen loads at Otter Creek.

ANALYSIS OF PRE-BMP CONSTITUENT LOADS AT URBAN STREAM SITES

The goal of the evaluation monitoring program is to determine if the implementation of BMPs has resulted in an improvement in the water quality of the stream. Previous research has identified an appropriate statistical approach that can be used to determine if statistically significant changes have occurred (Walker, 1994). The general approach is to compare constituent loads in stormflow during pre-BMP conditions to constituent loads in stormflow during post-BMP conditions. Because there is substantial variability in constituent loads, regression analyses are used to remove some of the natural variability of the constituent loads and to improve the chances of detecting a statistically significant difference between pre- and post-BMP conditions.

The purpose of this section of the report is to evaluate preliminary regressions for pre-BMP conditions for the urban streams, and assess the likelihood for detecting changes in the individual watersheds. Four urban streams were included in this analysis, using constituent load data collected through water year 1996. This analysis was limited to suspended solids, total phosphorus, and total recoverable copper loads in stormflow.

Regression analyses require specification of a dependent variable and a set of independent variables thought to control the variability of the dependent variable. For this report, separate analyses were conducted with suspended solids, total phosphorus, and total recoverable copper chosen as dependent variables. Measures related to precipitation and time were chosen for independent variables, because these were felt to be free from any changes that may be induced through the installation of BMPs. Several primary precipitation measures were computed for individual storms: total rainfall, 15- and 30-minute maximum rainfall intensities, and the Universal Soil Loss Equation (USLE) erosivity index (Wischmeier and Smith, 1978). Antecedent precipitation measures were computed as the total rainfall occurring 1-, 3-, 5- and 7-days prior to the beginning of each individual stormflow period.

Two periodic terms were computed to allow for the possibility of cyclical processes; the two terms were $\cos(2\pi T/365.25)$ and $\sin(2\pi T/365.25)$, where T is the beginning date of the storm, expressed as the number of years since 1904, and $\cos(x)$ and $\sin(x)$ are the trigonometric cosine and sine functions, respectively. Data was divided into three seasonal groups (spring, summer, fall). For the purposes of these analyses, spring was defined as March 1 through May 31, summer was defined as June 1 through August 31, and fall was defined as September 1 through December 15. A few winter storms were dropped from the analyses because there was not enough data to perform regressions for this period.

All possible regressions were computed for each of the four urban streams and the three dependent variables. Separate regression equations were determined for each group identified above. In some cases, the largest few constituent stormflow loads were dropped from the data set to allow for a more reasonable fit of the regression equation to the data. The constituent loads for the dropped storms were anomalously large, and could not be explained by any of the independent variables. One possible explanation is that there is a storage component to the sediment delivery process, and during some events the velocity in a stream may exceed a critical threshold and begin to scour the channel. Additional research is needed to define appropriate independent variables and bring the large loads back into the regressions. For Lincoln Creek, one storm was dropped due to insufficient rainfall data.

The resulting regressions are summarized for suspended solids, total phosphorus, and total recoverable copper in tables 6, 7 and 8, respectively. For most regressions one or two independent variables were used; in some cases a third independent variable was used to increase the precision of the regression equation.

Two measures are used to report on the ability of the regression equation to explain the variability of the constituent loads. The traditional R^2 value is reported, which is the portion of the total variability in the dependent variable that is “explained” by the regression. A second value, the standard error of the regression, is reported as a percentage of the mean value of the depen-

Table 6. Summary of regression results for storm-runoff loads of suspended solids for urban streams

[P_t, total precipitation; EI, Universal Soil Loss Equation Erosivity Index; AP_i, total precipitation for previous i day(s); I_n, n-minute maximum precipitation intensity; T, starting date of stormflow period, in years since 1904; sin(), trigonometric sine function; cos(), trigonometric cosine function; R^2, fraction of variation explained by the regression]

Group	Sample size	Independent variables	Adjusted R^2	Standard error[1]
		Nine Springs Creek Tributary		
Spring	16	P_t, $\cos(2\pi T)$, $\sin(2\pi T)$	0.7	44
Summer	12	P_t, I_{15}	.87	30
Fall	26	P_t, I_{15}, AP_1	.87	39
		Monroe Street Detention Pond Inlet		
Spring	14	EI	.56	77
Summer	20	I_{15}, EI	.85	42
Fall	8	P_t	.95	34
		Menomonee River		
Spring	7	EI	.98	24
Summer	18	P_t	.59	83
Fall	14	P_t	.69	37
		Lincoln Creek		
Spring	8	EI	.99	20
Summer	26	I_{15}, I_{30}	.46	84
Fall	9	P_t	.86	35

[1]Standard error is expressed as a percent of the mean value of the independent variable.

dent variable. The standard error is essentially a measure of the variability of the regression residuals, which indicates the variability remaining in the dependent variable. Previous work by Walker (1994) has indicated that the standard error, expressed as a percent of the mean, can be used as a measure for the minimum change in before and after conditions that would be statistically significant. Experience from the preliminary results from the Black Earth Creek priority watershed (Walker and Graczyk, 1993) indicates that the minimum detectable change could be somewhat less than the pre-BMP regression standard error.

The results for Lincoln Creek indicate that a change of 20–90 percent in suspended-solids stormflow load could be detected with a statistical test; the results for total phosphorus and total recoverable copper are less restrictive (25–50 percent). For the Menomonee River, a change in suspended solids, total phosphorus, and total recoverable copper load would have to be 20–80 percent to be detected. For the Monroe Street detention pond inlet, a change in suspended-solids, total-phosphorus, and total recoverable copper load of 30–80 percent would be needed to be statistically significant. For Nine Springs Creek Tributary, a change in suspended-solids, and total-phosphorus load of 30–45 percent would probably be detected with a statistical test but a change in total recoverable-copper stormflow load of 60–80 percent would be needed to be statistically significant. For each of these sites, the reported figures for potential minimum detectable change should be considered in the context of the potential for BMPs in the individual watersheds to achieve the minimum levels of change.

For all of the sites, the figures reported for minimum detectable change could potentially decrease as the regression relations are explored further. More sophisticated statistical techniques could be used to divide the data into groups which behave similarly, and additional research may reveal better ways to incorporate the antecedent precipitation measures into the regressions. Conversely, the reported figures for minimum detectable change could potentially increase as the few storms with anomalously large loads are brought back into the regressions.

Table 7. Summary of regression results for storm-runoff loads of total phosphorus for urban streams

[P_t, total precipitation; EI, Universal Soil Loss Equation Erosivity Index; AP_i, total precipitation for previous day(s); I_n, n-minute maximum precipitation intensity; T, starting date of stormflow period, in years since 1904; sin(), trigonometric sine function; cos(), trigonometric cosine function; R^2, fraction of variation explained by the regression]

Group	Sample size	Independent variables	Adjusted R^2	Standard error[1]
		Nine Springs Creek Tributary		
Spring	17	P_t, $\cos(2\pi T)$, $\sin(2\pi T)$	0.75	42
Summer	13	I_{15}, EI	.86	43
Fall	26	P_t, I_{15}, I_{30}	.87	38
		Monroe Street Detention Pond Inlet		
Spring	14	EI	.36	57
Summer	20	EI	.86	32
Fall	8	P_t, EI	.76	48
		Menomonee River		
Spring	7	EI	.95	32
Summer	17	P_t, EI	.73	69
Fall	14	P_t, AP_5	.71	44
		Lincoln Creek		
Spring	8	EI	.96	32
Summer	26	P_t, I_{15}, EI	.6	51
Fall	9	P_t	.67	44

[1]Standard error is expressed as a percent of the mean value of the independent variable.

Table 8. Summary of regression results for storm-runoff loads of copper for urban streams

[P_t, total precipitation; EI, Universal Soil Loss Equation Erosivity Index; AP_i, total precipitation for previous day(s); I_n, n-minute maximum precipitation intensity; T, starting date of stormflow period, in years since 1904; sin(), trigonometric sine function; cos(), trigonometric cosine function; R^2, fraction of variation explained by the regression]

Group	Sample size	Independent variables	Adjusted R^2	Standard error[1]
		Nine Springs Creek Tributary		
Spring	13	P_t, AP_7	0.72	60
Summer	13	I30, EI, AP_7	.95	87
Fall	24	P_t, $\cos(2\pi T)$, $\sin(2\pi T)$	.49	66
		Monroe Street Detention Pond Inlet		
Spring	11	P_t	.46	66
Summer	14	I_{30}, AP_3	.76	31
Fall	9	P_t	.9	36
		Menomonee River		
Spring	7	P_t	.96	29
Summer	14	P_t	.63	68
Fall	13	P_t, AP_5	.72	37
		Lincoln Creek		
Spring	8	EI	.95	29
Summer	26	P_t, I_{15}	.64	48
Fall	9	P_t	.88	25

[1]Standard error is expressed as a percent of the mean value of the independent variable.

ANALYSIS OF LOAD TRENDS AT RURAL STREAM SITES

For the eight rural streams, two have sufficient post-BMP storms for a final analysis, four have sufficient transitional storms for a preliminary analysis, and two have minimal BMP implementation that does not warrant further consideration. The final analysis will be reported elsewhere for the two streams with sufficient post-BMP storms (Brewery and Garfoot Creeks). The four streams with sufficient transitional data (Bower, Otter, Eagle, and Joos Valley Creeks) will be examined in this section. The remaining two streams (Rattlesnake and Kuenster Creeks) will not be examined due to minimal BMP implementation.

For Otter, Eagle, and Joos Valley Creeks, the storm-load data was divided into two periods: pre-BMP and transitional. The transitional period represents the time after the beginning of BMP installation and before completion of all planned BMPs. For Bower Creek, there were a sufficient number of transitional storms to allow for two transitional periods, labeled transitional-1 and transitional-2. The data was split into two periods sequentially to give an equal number of storms in the pre-BMP and transitional-2 periods. For this report, constituent-load data for suspended solids and total phosphorus were examined.

As discussed previously, a regression analysis can be used to help reduce the natural variability in the storm-load data (Walker and Graczyk, 1993; Walker, 1994). The overall set of independent variables used in the pre-BMP analysis for urban loads (previous section) was used for the rural sites. As with the urban analysis, the data were further divided into one of three groups, corresponding to one of three seasons: spring, summer, or fall. These seasons correspond roughly to the different processes of runoff generation and the different condition of soil cover during the year. In addition, for one site (Joos Valley Creek) it was necessary to break the data down further into groups corresponding to the antecedent moisture condition (AMC) classes used by SCS (U.S. Soil Conservation Service, 1972). For Joos Valley Creek, AMC-I, which corresponds to relatively dry pre-storm conditions, was further divided into the three seasons. The second group, AMC-II, which corresponds to relatively wet pre-storm conditions, was considered to be a separate group.

The resulting regressions for suspended sediment and total phosphorus are summarized in tables 9 and 10, respectively. In all cases, the regression analysis for a particular group is fit to both pre-BMP and traditional data. The tables present the individual sample sizes for the groups, the independent variables used in the final regression, and two terms which measure the goodness-of-fit of the regressions. The adjusted R^2 is a measure of the portion of the variability in the dependent variable that is accounted for by the regression. The standard error term is the standard deviation of the regression residuals (the unexplained portion of the dependent variable) divided by the average value of the dependent variable. Dividing by the average value of the dependent variable scales the data and provides a more comparable measure between the regressions.

For a particular site, the residuals from each regression group were combined to give a data set of residuals across all regression groups. Because the regression residuals represent the variability not accounted for by the independent variables, the variability remaining is due to either the effect of the BMPs or another factor not considered in the list of independent variables. The regression residuals, along with the actual storm loads, were tested for statistical differences between the pre-BMP and transitional periods using a non-parametric test (Mann-Whitney U test). The Mann-Whitney U test is a procedure for determining if the data from one data set is larger than the data from the second data set. The procedure works better than equivalent parametric tests if the underlying data deviates from normality.

The results of the statistical tests applied to the raw constituent loads and regression residuals for suspended solids and total phosphorus are presented in tables 11 and 12, respectively. Using a confidence level of 95 percent (there is a 5 percent chance that the conclusion that the data sets are different is wrong), the raw data reveal that there is no significant difference between the pre-BMP and transitional periods (significance levels are all greater than 0.05). For the regression residuals, most of the comparisons yield the same conclusion that there is no significant difference between the loads in the pre-BMP and transitional periods after accounting for natural variability. For Otter Creek, however, there appears to be a statistically-significant reduction in the suspended-solids loads (significance level of 0.035), and for Joos Valley Creek there appears to be a statistically-significant reduction in both the suspended-solids and total-phosphorus loads (significance levels of 0.012 and 0.004, respectively). For Otter Creek, an explanation of why a statistically-significant reduction in suspended solids has been detected and total phosphorus has not requires a detailed examination

Table 9. Summary of regression results for storm-runoff loads of suspended solids for rural streams

[P_t, total precipitation; EI, Universal Soil Loss Equation Erosivity Index; AP_i, total precipitation for previous i day(s); I_n, n-minute maximum precipitation intensity; T, starting date of stormflow period, in years since 1904; sin(), trigonometric sine function; cos(), trigonometric cosine function; R^2, fraction of variation explained by the regression]

Group	Sample size	Independent variables	Adjusted R^2	Standard error[1]
		Bower Creek		
Spring	14	EI	0.89	72
Summer	18	P_t, AP_1	.54	140
Fall	16	P_t+ AP_1, EI	.80	93
		Otter Creek		
Spring	14	AP_1, P_t + AP_5	.84	60
Summer	17	EI	.66	100
Fall	15	$\cos(2\pi T)$	.61	83
		Eagle Creek		
Spring	14	EI	.76	96
Summer	25	EI, AP_3	.93	56
Fall	5	P_t + AP_1	.92	45
		Joos Valley Creek		
AMC I, Spring	8	P_t	.56	110
AMC I, Summer	22	EI, I_{30}	.71	120
AMC I, Fall	4	EI	.99	16
AMC II	12	EI	.98	34

[1]Standard error is expressed as a percent of the mean value of the independent variable.

Table 10. Summary of regression results for storm-runoff loads of total phosphorus for rural streams

[P_t, total precipitation; EI, Universal Soil Loss Equation Erosivity Index; AP_i, total precipitation for previous i day(s); I_n, n-minute maximum precipitation intensity; T, starting date of stormflow period, in years since 1904; sin(), trigonometric sine function; cos(), trigonometric cosine function; R^2, fraction of variation explained by the regression]

Group	Sample size	Independent variables	Adjusted R^2	Standard error[1]
		Bower Creek		
Spring	14	EI	0.72	82
Summer	17	P_t, AP_1, P_t	.46	130
Fall	16	P_t+ AP_1, EI	.79	79
		Otter Creek		
Spring	14	P_t + AP_5, AP_1	.84	58
Summer	17	EI	.69	82
Fall	15	$\cos(2\pi T)$	.51	62
		Eagle Creek		
Spring	14	P_t + AP_1	.54	94
Summer	25	EI, AP_3	.93	54
Fall	5	P_t	.90	47
		Joos Valley Creek		
AMC I, Spring	8	P_t	.59	100
AMC I, Summer	22	EI, I_{30}	.78	88
AMC I, Fall	4	EI	.99	15
AMC II	12	EI	.98	32

[1]Standard error is expressed as a percent of the mean value of the independent variable.

Table 11. Results of Mann-Whitney U test comparing suspended solids storm loads from pre-BMP to transitional periods

[BMP, Best-Management Practice; pre-BMP, period before installation of BMPs; Transitional-1, first period after start of BMP installation; Transitional-2, period succeeding Transitional-1]

Group 1		Group 2		Significance level	
Period	**Sample size**	**Period**	**Sample size**	**Raw data**	**Residuals**
		Bower Creek			
Pre-BMP	18	Transitional-1	11	0.611	0.672
Pre-BMP	18	Transitional-2	18	.924	.752
		Otter Creek			
Pre-BMP	29	Transitional-1	16	.286	.035
		Eagle Creek			
Pre-BMP	28	Transitional-1	16	.113	.542
		Joos Valley Creek			
Pre-BMP	21	Transitional-1	25	.229	.012

Table 12. Results of Mann-Whitney U test comparing total phosphorus storm loads from pre-BMP to transitional periods

[BMP, Best-Management Practice; pre-BMP, period before installation of BMPs; Transitional-1, first period after start of BMP installation; Transitional-2, period succeeding Transitional-1]

Group 1		Group 2		Significance level	
Period	**Sample size**	**Period**	**Sample size**	**Raw data**	**Residuals**
		Bower Creek			
Pre-BMP	18	Transitional-1	11	0.589	0.653
Pre-BMP	18	Transitional-2	18	.825	.327
		Otter Creek			
Pre-BMP	29	Transitional-1	16	.538	.981
		Eagle Creek			
Pre-BMP	28	Transitional-1	16	.092	.903
		Joos Valley Creek			
Pre-BMP	21	Transitional-1	25	.146	.004

of the BMPs installed. For the streams and constituents without significant differences, one of two possibilities exist: (1) either the BMP installation to date has not reduced the loads of the constituent in question, or (2) the BMP installation to date has reduced the loads, but the variability remaining in the residuals is masking the change. It is possible that completion of the BMP installations and collection of post-BMP loads after the practices have had enough time to begin working will result in more statistically-significant decreases in the constituent loads.

CONCLUSIONS

For the five rural streams with continuous dissolved-oxygen monitoring, there have been some improvements in the dissolved-oxygen concentrations. The results, however, are not consistent from year to year. Thus it is not possible to attribute the changes in dissolved oxygen concentration to the implementation of BMPs.

For the four urban stream sites, an evaluation of regressions for pre-BMP loads resulted in a wide range of minimum detectable changes that likely could be detected after BMP implementation. For three of the sites, the minimum detectable change ranges from 20–90 percent for the three constituents considered. It is likely that the expected change from BMPs would be less than these values, hence could not be detected statistically. For one site (Nine Springs Creek Tributary) the minimum statistically detectable change for suspended solids and total phosphorus ranged from 30–45 percent, which is well within the range expected for urban BMPs. Thus for this site it is possible that post-

BMP changes would be detected using statistical techniques.

For the eight rural streams sites, two sites had sufficient post-BMP data for analysis and the results will be reported elsewhere. Of the remaining six rural streams, four had sufficient transitional data to warrant a preliminary analysis. For all of the streams, the BMPs implemented during the transitional period have not significantly reduced the actual storm loads for suspended solids and phosphorus. Multiple regressions were used to remove some of the natural variability in the data. Based on the residual analysis, for Otter Creek there appears to be a significant reduction in suspended-solids load, and for Joos Valley Creek there appears to be a significant reduction in the suspended-solids and total-phosphorus loads after accounting for natural variability. It is possible that the other sites will also show statistically significant reductions in suspended solids and total phosphorus if additional BMPs are implemented.

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APPENDIX

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Brewery Creek							
84/10/18	1745	84/10/19	1700	2.78	1.5	35	140
84/11/01	0015	84/11/01	2245	.93	.48	7.4	28
84/12/28	0045	84/12/28	2145	s/m	1.3	22	180
85/02/21	0430	85/02/25	0700	s/m	9.6	120	1,500
85/07/24	1930	85/07/26	2230	6.85	14	500	2,000
85/08/12	2145	85/08/13	1800	.94	.25	1.2	13
85/08/25	0200	85/08/26	1000	1.70	.53	2.6	--
85/09/04	2330	85/09/05	2115	1.53	.56	2.3	38
85/09/09	0015	85/09/09	2345	1.40	1.3	25	130
85/10/12	0315	85/10/13	0200	.80	.76	3.3	--
85/10/23	1515	85/10/24	1400	.59	.39	2.3	20
85/10/31	1800	85/11/02	1100	2.77	2.4	20	190
85/11/17	2245	85/11/19	0800	.63	.85	3.5	55
86/03/09	2200	86/03/10	2300	s/m	.67	8.1	--
86/03/17	1200	86/03/20	0100	s/m	3.1	60	330
86/05/15	1500	86/05/16	0200	.58	.28	1.2	18
86/05/17	0100	86/05/18	0600	1.09	.96	8.1	78
86/06/22	0100	86/06/22	2300	1.16	.77	1.1	24
89/10/05	0745	89/10/05	1500	--	.020	.040	1.1
90/03/08	0930	90/03/09	0500	.67	1.8	590	750
90/03/11	0600	90/03/12	0200	.50	2.5	160	820
90/03/13	1815	90/03/14	0600	.84	.89	48	250
90/06/02	1315	90/06/03	1000	1.54	.59	35	140
90/06/28	2330	90/06/29	1900	2.14	4.1	250	1,100
91/04/12	1230	91/04/13	1230	1.17	.75	8.3	85
91/04/14	0600	91/04/14	2400	.80	.61	4.1	54
91/04/28	2045	91/04/29	1100	1.24	.29	7.1	47
91/05/05	0900	91/05/05	2400	1.08	.24	3.4	25
91/07/01	1415	91/07/02	1500	1.29	.34	1.7	27
91/07/07	1430	91/07/08	1315	1.11	.52	3.1	56
91/08/08	0130	91/08/08	0900	2.24	.14	.97	9.9
91/10/24	2000	91/10/26	0100	3.55	2.9	120	740
91/11/01	0030	91/11/02	1330	.81	.88	5.4	90
91/11/29	1900	91/11/30	1800	.61	.44	2.3	32
92/02/27	1030	92/02/28	0500	s/m	.87	6.7	130
92/02/28	0845	92/02/29	0300	s/m	.98	14	160
92/03/01	1200	92/03/02	0700	s/m	.66	20	120

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Brewery Creek—Continued							
92/07/13	1500	92/07/15	0300	1.49	.34	--	36
92/08/29	0330	92/08/29	1100	1.21	.037	.13	.78
92/09/16	1100	92/09/17	1800	1.19	.25	.51	27
92/09/18	0330	92/09/19	1700	.73	.33	.47	18
92/10/15	1800	92/10/15	2300	.45	.019	.020	.28
92/11/20	0300	92/11/22	0600	2.55	1.4	7.5	100
93/03/06	1000	93/03/07	0815	s/m	.60	13	440
93/03/07	1200	93/03/08	0800	s/m	1.2	9.3	490
93/03/08	1300	93/03/09	0400	s/m	.83	7.8	380
93/03/16	0700	93/03/17	0800	s/m	1.7	73	640
93/03/24	1000	93/03/25	0700	s/m	2.1	36	330
93/03/25	1000	93/03/26	0800	s/m	2.3	67	460
93/03/26	1200	93/03/27	0800	s/m	2.3	--	160
93/03/27	1200	93/03/28	0800	s/m	1.2	16	98
93/03/28	1100	93/03/29	0700	s/m	2.9	210	590
93/03/31	0300	93/04/01	0300	s/m	2.5	55	250
93/06/07	1035	93/06/08	1000	2.39	2.5	110	470
93/06/17	1000	93/06/18	1200	.43	.93	18	67
93/07/05	0430	93/07/07	0900	4.58	16	1,300	4,000
93/07/07	1800	93/07/08	0900	1.03	1.3	130	460
93/07/09	0100	93/07/10	0400	1.47	5.1	250	570
93/07/17	1100	93/07/18	0400	.86	.84	42	87
93/07/25	0100	93/07/26	0400	1.35	2.1	83	300
93/07/27	2200	93/07/28	1900	.88	1.4	25.8	120
93/08/15	0500	93/08/16	2000	2.48	4.7	88.6	470
93/09/13	0800	93/09/15	1500	2.12	2.9	12.1	130
94/02/18	1300	94/02/21	1200	--	4.9	220	780
94/03/05	1100	94/03/06	0800	--	2.8	72	510
94/03/06	0900	94/03/07	0700	--	1.7	30	110
94/06/23	1230	94/06/24	2100	--	1.2	4.2	62
94/06/25	2100	94/06/27	0100	--	.66	2.1	16
94/07/03	2345	94/07/05	2300	--	5.9	200	930
94/08/10	1530	94/08/12	0200	--	1.1	2.5	32
94/09/14	0400	94/09/15	0500	--	.65	4.1	36
94/11/27	1215	94/11/28	1815	1.15	9.8	13	57
95/03/11	0900	95/03/12	0900	s/m	19	130	450
95/05/09	1900	95/05/11	0015	.85	6	1.4	19

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Brewery Creek—Continued							
95/10/05	1800	95/10/08	0200	1.82	8.6	4.3	41
95/11/01	0945	95/11/03	1600	1.49	15	6.2	54
96/01/17	2300	96/01/22	2000	.87	31	92	410
96/02/09	1500	96/02/12	0100	s/m	33	14	360
96/02/26	1500	96/02/27	2300	s/m	38	160	720
96/05/09	2100	96/05/11	2000	1.94	27	320	1,100
96/06/01	1500	96/06/02	2000	1.13	4.6	2.5	14
96/06/05	2100	96/06/08	1600	1.37	11	3	36
96/06/16	2245	96/06/20	0400	4.55	80	200	960
96/07/17	2200	96/07/20	0500	2.64	33	47	290
96/08/05	1600	96/08/08	0400	1.89	12	2	34
96/10/29	0930	96/10/30	1500	1.29	5.8	3.6	12
97/01/04	0300	96/01/05	1145	.55	20	66	300
97/01/21	2200	97/01/23	0800	s/m	26	29	240
97/02/18	1000	97/02/19	0900	s/m	53	170	900
97/02/20	1400	97/02/22	0300	1.00	39	150	770
97/02/28	1400	97/03/02	0700	s/m	37	140	560
97/03/09	0500	97/03/10	0700	.49	18	84	300
97/04/30	1600	97/05/01	2100	1.38	6.1	3.3	21
97/06/15	1100	97/06/16	1800	1.88	4.8	4	32
97/06/21	0400	97/06/21	2400	1.69	7.2	8.1	55
97/07/08	0200	97/07/09	0300	1.29	5.8	1.9	22
97/07/20	2300	97/07/22	0200	1.60	7	5.7	58
98/02/15	1200	98/02/17	1900	.23	6.5	3.6	13
98/03/30	1200	98/04/02	1200	3.99	58	270	1,200
98/05/07	1000	98/05/09	1200	.95	8.4	2.6	--
98/06/11	0200	98/06/12	1100	.93	4.1	1.3	13
98/06/18	1100	98/06/20	1000	2.27	29	64	330
98/06/27	0200	98/06/29	1800	2.13	31	38	220
98/09/14	0200	98/09/16	1600	2.46	11	1.3	28
Garfoot Creek							
84/10/18	1200	84/10/19	2200	2.64	3.1	37	210
84/10/31	2400	84/11/01	1800	1.13	1.1	16	76
84/12/27	2200	84/12/29	0900	s/m	2.4	45	140
85/02/21	0200	85/02/25	0100	s/m	6.3	62	470
85/07/24	1915	85/07/26	0500	6.56	7.5	65	710

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Garfoot Creek—Continued							
85/09/04	2400	85/09/05	1300	1.38	.49	1.7	22
85/09/09	0015	85/09/09	2100	1.63	2.2	17	130
85/09/23	0300	85/09/24	0300	1.20	.57	1.9	--
85/10/11	2345	85/10/12	2100	.85	1.1	14	--
85/10/23	1600	85/10/24	0700	.70	.62	9.8	46
85/10/31	1626	85/11/02	1400	2.79	5.3	34	370
85/11/18	0300	85/11/19	0900	.73	1.6	17	98
86/03/09	1600	86/03/11	0600	s/m	1.7	26	110
86/03/16	1200	86/03/20	0200	s/m	7.7	59	610
86/05/15	1400	86/05/16	0500	.72	.53	14	27
86/05/17	0100	86/05/18	0400	1.15	1.2	15	75
89/10/05	0930	89/10/06	0600	--	.21	.27	6.4
90/01/16	1845	90/01/17	2200	s/m	1.4	13	190
90/03/11	0600	90/03/12	0400	.48	2.9	53	330
90/03/13	0600	90/03/14	1300	.76	1.3	30	160
90/03/14	1600	90/03/15	1500	1.12	2.0	31	230
90/06/02	1300	90/06/03	0100	1.48	.42	23	100
90/06/28	2330	90/06/29	2300	2.45	3.0	77	530
90/08/19	1630	90/08/20	1200	--	.81	4.6	61
91/03/01	0945	91/03/02	2200	1.51	3.2	53	370
91/03/22	2130	91/03/23	0700	.74	.33	4.2	28
91/04/12	1500	91/04/13	1400	1.74	2.2	74	210
91/04/14	0600	91/04/14	2400	.99	1.9	58	200
91/08/08	0200	91/08/08	1500	2.34	.30	--	12
91/11/01	0900	91/11/02	0100	1.40	1.3	15	150
91/11/29	2000	91/11/30	1300	.87	.98	13	76
92/02/26	1400	92/02/27	0100	s/m	.30	--	11
92/02/27	1045	92/02/28	0100	s/m	.68	9.0	54
92/02/28	1130	92/02/28	2400	s/m	.44	1.5	21
92/09/16	1200	92/09/17	0330	1.34	.69	7.4	46
92/09/18	0330	92/09/18	1800	.89	.70	5.2	48
92/11/19	2000	92/11/21	2300	2.68	3.4	43	420
92/12/15	1600	92/12/16	1200	1.30	1.2	7.4	400
93/03/24	1300	93/03/25	0830	s/m	2.1	24	240
93/03/25	1030	93/03/26	1000	s/m	3.4	41	300
93/03/26	1300	93/03/27	0500	s/m	1.7	14	130
93/03/27	1240	93/03/28	0400	s/m	1.3	9.1	100

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Garfoot Creek—Continued							
93/03/28	1000	93/03/29	0300	s/m	2.7	44	290
93/03/31	0400	93/04/01	0400	s/m	3.7	28	210
93/04/07	2300	93/04/08	1700	.62	1.3	13	60
93/04/15	0100	93/04/16	1200	1.55	4.2	35	240
93/04/19	1300	93/04/20	2300	1.69	3.8	37	180
93/06/07	1045	93/06/08	2000	1.97	2.8	31	180
93/06/17	1800	93/06/18	1200	1.09	.99	13	54
93/07/05	0500	93/07/07	0200	3.98	7.7	130	730
93/07/08	1300	93/07/10	0400	1.81	5.9	110	490
93/07/10	1800	93/07/11	0500	.45	1.1	12	63
93/07/25	0300	93/07/25	2400	1.48	2.5	43	220
93/07/27	2200	93/07/28	1500	.44	.92	5.92	38
93/08/15	0500	93/08/16	1300	2.35	3.6	30.8	230
93/08/23	1600	93/08/24	0700	1.26	1.3	14.2	65
93/09/13	1000	93/09/15	0500	2.27	2.7	18.6	140
94/02/19	0100	94/02/21	0700	--	6.4	74	650
94/03/05	1200	94/03/06	0500	--	1.2	9	89
94/03/06	1100	94/03/07	0500	--	1.2	5.7	63
94/08/10	1200	94/08/11	1500	--	1.4	12	76
94/09/14	0500	94/09/14	2000	--	.59	5.2	22
94/11/27	1015	94/11/28	0800	1.28	12	14	74
95/03/11	1000	95/03/12	0800	s/m	13	24	99
95/03/20	0200	95/03/21	1500	.74	14	2.9	31
95/04/10	1300	95/04/11	1200	.54	9.4	1.9	19
95/04/18	0500	95/04/19	0200	.96	13	6.8	56
95/05/09	2000	95/05/10	2400	.60	14	3.2	31
95/05/27	1400	95/05/28	1800	2.40	29	43	180
95/08/16	1600	95/08/17	1800	2.33	18	25	120
95/08/19	0800	95/08/20	0900	1.03	15	14	69
95/10/05	2100	95/10/07	1500	2.28	21	20	110
95/11/01	1300	95/11/03	1200	1.71	27	34	130
96/01/17	2000	96/01/20	0400	.89	35	120	440
96/02/09	0900	96/02/12	0800	s/m	32	190	300
96/02/26	1600	96/02/28	1600	.55	41	61	300
96/05/09	2300	96/05/11	2200	1.78	45	98	560
96/06/01	1600	96/06/02	2000	1.32	13	7.8	46

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Garfoot Creek—Continued							
96/06/06	0200	96/06/08	2000	1.77	29	15	100
96/06/16	2300	96/06/18	2200	3.43	82	60	430
96/07/18	0100	96/07/19	1000	1.92	18	17	85
96/08/05	1800	96/08/08	0500	2.39	24	16	77
96/10/29	1000	96/10/30	1400	1.35	12	3.6	33
97/02/17	2000	97/02/19	0600	s/m	32	48	310
97/02/20	1400	97/02/22	1400	.87	42	43	300
97/03/01	0100	97/03/02	0500	s/m	26	34	210
97/03/09	0600	97/03/10	1000	s/m	14	17	81
97/04/30	1900	97/05/01	2100	1.62	14	8.5	52
97/06/15	1730	97/06/17	0400	1.99	10	5.3	37
97/06/21	0800	97/06/22	0700	1.23	7.3	3.2	22
97/07/08	0400	97/07/08	2300	1.51	8.1	5.6	30
97/07/21	0100	97/07/21	2100	.89	6.2	2.7	20
97/07/27	0700	97/07/28	0200	1.04	7.6	4	22
97/08/12	0400	97/08/13	0200	1.13	5.9	1.4	12
98/02/15	1200	98/02/18	0900	.12	23	5.5	56
98/03/30	1200	98/04/02	0100	4.49	130	240	1,400
98/04/07	1800	98/04/10	0500	1.29	26	9.9	36
98/04/13	1000	98/04/17	1400	1.57	53	--	180
98/05/07	0600	98/05/08	1200	.71	14	--	34
98/06/11	0400	98/06/12	1500	.36	13	--	39
98/06/18	1200	98/06/19	2300	.78	46	48	270
98/06/27	2200	98/06/29	0400	.83	50	52	320
98/07/03	1000	98/07/04	1800	1.05	27	37	140
98/09/14	0400	98/09/15	1500	2.84	23	7.7	120
Eagle Creek							
91/04/29	0200	91/04/29	2200	1.81	5.1	2,100	3,800
91/05/05	0800	91/05/05	2230	1.29	1.7	61	210
91/05/15	2130	91/05/17	0200	.85	6.9	3,200	4,700
91/05/31	0900	91/05/31	2000	.50	1.2	250	280
91/07/21	1715	91/07/21	2400	1.99	1.6	220	430
91/08/07	1540	91/08/08	1500	1.88	1.6	62	140
91/10/23	2325	91/10/24	1200	1.21	.88	52	200
91/11/01	0050	91/11/01	2300	2.75	7.0	620	1,400
91/11/17	1900	91/11/18	1200	1.15	1.9	120	250

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
			Eagle Creek—Continued				
92/03/01	1100	92/03/02	0400	s/m	1.3	140	220
92/03/03	2000	92/03/04	0900	.41	.92	48	130
92/03/09	0100	92/03/09	1300	.82	1.1	72	170
92/04/20	1500	92/04/21	0900	1.24	1.8	210	300
92/05/16	1645	92/05/16	2400	1.54	.66	83.6	160
92/05/21	1730	92/05/21	2200	.51	.24	6.3	22
92/05/22	1815	92/05/23	0300	.44	.47	26	84
92/07/13	1400	92/07/13	2400	1.27	.73	43	80
92/08/01	1900	92/08/02	0200	1.03	.49	16	31
92/09/16	0200	92/09/16	2400	3.99	1.2	1,700	3,300
93/03/26	1200	93/03/27	0200	s/m	1.1	35	87
93/03/29	1100	93/03/29	2400	s/m	9.9	27	42
93/03/30	1300	93/03/31	2100	1.67	4.7	420	610
93/04/11	0200	93/04/12	0600	.79	2.4	50	100
93/04/18	2100	93/04/20	0600	2.22	7.0	450	960
93/04/27	0100	93/04/27	1400	1.02	1.4	74	180
93/06/08	1500	93/06/09	0400	1.47	4.4	950	2,000
93/07/02	0010	93/07/02	1100	1.47	5.5	420	1,100
93/07/03	1400	93/07/04	0600	1.06	6.1	1,500	3,000
93/07/27	1715	93/07/28	0400	.76	1.5	120	220
93/08/09	0600	93/08/09	2000	1.09	2.8	310	540
93/08/15	0400	93/08/15	1800	1.18	2.2	73	160
93/08/18	0900	93/08/18	2100	1.30	3.6	290	640
93/08/30	0400	93/08/30	2000	1.69	4.6	410	1,000
93/09/13	1000	93/09/14	1100	1.72	3.6	120	300
94/02/18	1300	94/02/20	0900	--	12	1,700	3,400
94/03/04	1100	94/03/05	0800	--	3.6	380	790
94/03/05	1100	94/03/06	1000	--	2.9	130	450
94/04/15	0140	94/04/16	0600	--	2.2	67	140
94/04/24	2000	94/04/25	1900	--	2.0	54	110
94/04/26	0010	94/04/27	0200	--	5.2	1,900	2,900
94/07/07	1300	94/07/08	1100	--	1.9	75	170
94/08/10	0110	94/08/11	1000	--	6.0	390	800
94/08/18	0315	94/08/18	2100	--	1.7	95	180
94/08/30	0835	94/08/31	0300	--	1.5	51	110
94/09/13	2035	94/09/15	0300	--	5.5	340	920
94/09/23	1615	94/09/24	1100	--	1.4	30	63

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Eagle Creek—Continued							
94/10/17	1600	94/10/18	1200	.79	15	28	80
95/08/13	0400	95/08/13	1700	1.55	8.2	11	34
95/08/13	2000	95/08/14	2000	4.81	210	5,300	10,000
95/10/23	0830	95/10/24	0200	1.25	9.7	4	6.7
96/03/13	1000	96/03/14	0700	s/m	28	230	570
96/03/14	1000	96/03/15	0800	s/m	23	77	320
96/03/15	1100	96/03/16	0600	s/m	16	58	150
96/03/16	1200	96/03/17	0400	s/m	12	57	87
96/03/24	0200	96/03/25	0900	1.55	88	1,500	2,900
96/06/16	1900	96/06/17	1300	1.29	10	12	30
96/06/17	1500	96/06/18	1100	.63	13	14	32
Joos Valley Creek							
90/08/17	1850	90/08/18	0200	1.37	.96	170	420
90/08/26	0545	90/08/26	1500	1.75	2.8	750	1,600
91/04/29	0200	91/04/29	1600	2.11	1.7	840	1,500
91/05/05	0730	91/05/05	2000	1.25	.64	26	57
91/05/15	2000	91/05/17	0200	1.21	1.8	390	850
91/05/31	0850	91/05/31	1900	.57	.40	36	78
91/07/21	1710	91/07/22	1100	1.24	.68	27	70
91/08/07	1500	91/08/08	1100	2.27	.63	11	34
91/10/23	2250	91/10/24	1300	.83	.34	3.4	12
91/10/31	2200	91/11/01	2200	2.87	2.1	110	330
91/11/17	1800	91/11/18	1400	1.21	.96	14	62
92/03/01	1000	92/03/02	0400	s/m	.63	16	68
92/03/03	1400	92/03/04	0800	.37	.47	1.5	11
92/03/08	2400	92/03/09	1100	.86	.45	20	49
92/04/20	1300	92/04/21	0700	1.24	.77	56	120
92/05/16	1500	92/05/16	2200	1.62	.34	54	110
92/05/21	1700	92/05/21	2400	.74	.22	13	35
92/05/22	1800	92/05/23	0300	.49	.27	12	31
92/06/17	0400	92/06/17	1800	.57	.25	2.8	7.7
92/07/02	0500	92/07/02	1500	.72	.23	4.2	9.2
92/07/13	1300	92/07/14	0200	1.32	.40	7.1	21
92/07/22	1000	92/07/23	0300	1.19	.37	1.4	5.7
92/08/01	1800	92/08/02	1300	1.24	.57	24	73
92/09/16	0100	92/09/16	2200	4.19	5.4	910	1,700

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Joos Valley Creek—Continued							
93/03/24	1100	93/03/25	0500	s/m	.38	1.4	14
93/03/26	1300	93/03/27	0200	s/m	.47	8.3	56
93/03/30	1100	93/03/31	2000	1.50	2.1	86	25
93/04/11	0100	93/04/12	0200	.53	.87	4.0	15
93/04/16	1200	93/04/17	0100	.64	.60	4.2	16
93/04/18	2200	93/04/20	0300	2.07	2.7	130	320
93/04/27	0100	93/04/28	0200	1.07	1.5	22	63
93/06/08	1500	93/06/08	2310	1.50	1.8	630	900
93/07/01	2400	93/07/02	0940	1.33	1.2	180	410
93/07/03	1400	93/07/03	2100	.90	2.2	880	1,600
93/07/27	1700	93/07/27	2300	.75	.54	64	130
93/08/09	0600	93/08/09	1400	1.17	.92	110	220
93/08/15	0300	93/08/15	1500	1.19	.73	12	330
93/08/18	0900	93/08/18	0900	1.08	.87	53	140
93/08/30	0300	93/08/30	1300	1.78	1.4	130	290
94/02/18	1200	94/02/20	0800	--	5.7	740	1500
94/03/04	1000	94/03/05	0500	--	1.8	160	350
94/03/05	1100	94/03/06	0800	--	1.3	28	250
94/04/15	0110	94/04/16	0300	--	.84	16	35
94/04/24	2110	94/04/26	2100	--	2.8	670	1,200
94/07/07	1122	94/07/08	1000	--	.77	19	60
94/08/10	0425	94/08/11	1900	--	2.3	130	300
94/08/18	0325	94/08/18	2300	--	.68	22	70
94/08/13	0740	94/08/30	2100	--	.5	5.1	17
94/09/13	2035	94/09/14	2300	--	2.1	150	420
94/09/23	1550	94/09/23	2300	--	.31	4.2	9.5
94/10/17	1700	94/10/18	0800	.86	5.8	5	16
95/08/13	2000	95/08/14	1300	5.13	110	6,200	9,800
95/10/23	0700	95/10/24	0200	1.25	4.4	.39	1.8
96/03/11	1100	96/03/12	0600	s/m	3.6	.57	6.3
96/03/12	1100	96/03/13	0900	s/m	7.8	2.5	22
96/03/13	1100	96/03/14	1100	s/m	20	50	230
96/03/14	1200	96/03/15	0700	s/m	14	12	86
96/03/15	1000	96/03/16	0900	s/m	11	5.5	49
96/03/16	1300	96/03/17	0900	s/m	8.2	6.8	31
96/03/24	0100	96/03/26	0100	1.70	58	940	1,800
96/06/16	1200	96/06/18	2000	2.25	14	8.9	20

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Bower Creek							
90/10/17	2040	90/10/20	0925	.38	3.6	12	280
91/03/01	1500	91/03/04	1100	1.05	100	100	--
91/03/05	1700	91/03/08	1500	s/m	12	13	520
91/03/18	1300	91/03/25	0900	s/m	160	160	1,800
91/04/09	1100	91/04/12	2000	s/m	48	48	460
91/04/12	2400	91/04/17	2400	.71	260	260	1,500
91/06/14	0500	91/06/15	1545	1.40	1.2	9.7	70
91/10/29	1000	91/10/31	1400	1.02	1.00	1.8	58
91/11/01	1325	91/11/04	0600	.35	.91	.55	77
91/11/18	0700	91/11/20	0905	.23	.90	.24	32
91/11/29	1805	91/12/02	1610	.78	10	64	590
91/12/12	0825	91/12/14	0700	.61	14	64	700
92/03/29	1500	92/03/31	0940	.28	3.9	5.9	120
92/03/31	1200	92/04/02	1100	.12	3.9	11	150
92/04/10	1700	92/04/13	1535	.43	12	75	440
92/04/15	1200	92/04/18	0935	2.07	34	710	2,900
92/04/19	1355	92/04/20	1815	.19	3.4	11	110
92/04/20	1945	92/04/22	0910	.36	7.2	72	430
92/07/13	1820	92/07/16	0500	.71	.48	.24	13
92/09/16	0725	92/09/17	0520	1.39	.95	2.9	110
92/09/18	0240	92/09/20	0800	1.48	13	97	950
92/09/26	1000	92/09/30	0510	1.11	3.3	2.7	120
92/11/01	1900	92/11/03	2300	1.27	8.1	40	550
92/11/08	2300	92/11/12	0401	.34	4.1	3.7	130
92/11/12	1200	92/11/14	1001	.34	4.7	6.3	170
92/11/20	0005	92/11/22	0530	1.60	38	270	2,500
92/12/15	0715	92/12/17	2216	1.02	47	180	1,900
92/12/29	0600	92/12/31	2301	s/m	1.6	.77	58
93/03/02	1140	93/03/18	1801	s/m	29	30	1,600
93/03/24	0859	93/03/31	1501	s/m	22	26	1,100
93/04/04	1130	93/04/07	1101	s/m	9.5	22	350
93/04/07	1345	93/04/10	0101	.76	28	290	1,700
93/04/11	1459	93/04/14	0801	s/m	7.4	8.0	230
93/04/15	0559	93/04/19	0301	1.01	46	420	2,400
93/04/19	0900	93/04/23	0801	.49	32	140	1,300
93/04/27	1729	93/04/29	1401	.55	8.5	27	340
93/05/30	1245	93/06/03	0531	.92	4.0	2.5	110

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Bower Creek—Continued							
93/06/08	0300	93/06/11	1201	2.51	38	1,100	3,600
93/06/14	0225	93/06/16	0021	.96	6.9	110	480
93/08/05	2300	93/08/08	1700	1.18	1.6	5.1	--
93/10/15	1730	93/10/19	0300	--	1.8	1.4	19
93/10/20	2200	93/10/23	2200	--	2.2	1.5	78
93/11/12	2200	93/11/18	0600	--	3.2	1.2	68
93/11/26	0700	93/11/29	0900	--	2.9	3.6	89
94/02/19	0700	94/02/25	0300	--	78	46	930
94/03/04	1200	94/03/09	2200	--	36	48	770
94/04/12	1500	94/04/14	1000	--	3.3	7.3	65
94/04/15	0245	94/04/17	0900	--	5.9	37	230
94/04/24	2000	94/04/27	0345	--	45	2,200	6,000
94/07/04	0100	94/07/09	2100	--	3.2	6.6	100
96/04/18	2200	96/04/19	2355	.29	39	4	93
96/04/20	0900	96/04/21	1700	.55	110	71	530
96/06/07	0300	96/06/08	2300	1.51	270	220	1,500
96/06/10	1000	96/06/12	2355	.20	52	5.3	160
96/06/17	0200	96/06/20	0500	3.16	730	1200	5,000
96/07/29	1700	96/07/30	2300	.30	28	28	240
97/01/04	1200	97/01/06	2355	.84	21	.2	15
97/01/22	0300	97/01/24	2355	s/m	78	1.3	84
97/02/18	1100	97/02/20	2355	s/m	480	11	480
97/03/21	1300	97/03/24	2355	s/m	260	9.8	510
97/03/26	0900	97/03/29	2355	s/m	760	180	1,500
97/04/30	2200	97/05/02	1700	1.83	68	30	270
97/06/07	0900	97/06/09	0400	1.06	6.6	.17	8.8
97/06/12	0400	97/06/13	0500	.46	4.2	.16	6.7
97/06/20	0300	97/06/21	0400	1.28	73	230	560
97/06/21	0900	97/06/22	2000	.79	99	63	440
97/06/23	0500	97/06/23	2200	.19	12	.65	26
Otter Creek							
90/09/06	1940	90/09/08	1845	1.53	1.5	7.1	63
90/09/14	0540	90/09/18	2335	1.67	6.5	26	190
90/11/05	0610	90/11/06	1030	.79	1.2	1.2	20
91/02/03	0300	91/02/08	1400	s/m	10	11	180
91/03/01	1100	91/03/04	1600	s/m	5.3	27	--

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Otter Creek—Continued							
91/06/14	1735	91/06/18	0300	2.24	5.2	35	230
91/10/24	1200	91/10/26	1245	1.85	2.0	8.3	57
91/10/26	1245	91/10/27	2300	.46	1.4	1.6	23
91/10/29	0225	91/10/30	1910	--	2.6	11	83
91/11/01	1200	91/11/03	0005	.53	2.2	8.1	70
91/11/14	1535	91/11/17	0155	.46	2.0	3.0	24
91/11/18	0140	91/11/20	1810	.39	2.7	7.6	45
91/11/29	2015	91/12/02	2235	1.38	6.7	19	150
92/02/27	1200	92/03/01	0900	s/m	4.1	12	110
92/03/01	0900	92/03/03	0900	s/m	4.1	14	130
92/03/05	2100	92/03/08	1100	.37	5.8	15	100
92/03/09	0335	92/03/10	1930	.55	4.8	24	98
92/03/24	1200	92/03/28	0700	s/m	6.0	8.3	82
92/04/10	1800	92/04/13	0500	.81	4.1	19	82
92/04/16	0500	92/04/18	0540	.80	4.5	25	110
92/09/14	1230	92/09/15	0600	1.01	.24	.27	2.8
92/09/16	0950	92/09/17	0640	1.00	.41	1.1	13
92/09/18	0440	92/09/19	0735	1.09	.82	3.1	25
92/09/26	2110	92/09/28	1700	.74	.63	.52	5.2
92/11/01	1600	92/11/03	1600	1.55	2.4	6.5	57
92/11/12	0800	92/11/13	1901	.39	.92	.62	9.3
92/11/19	2300	92/11/22	1701	.84	4.2	16	120
92/11/25	1900	92/11/27	1901	.35	2.7	3.0	53
92/12/15	0520	92/12/17	1301	.97	7.6	32	220
92/12/29	0744	92/12/30	0731	.30	.83	.44	7.8
93/03/24	1050	93/04/01	1201	s/m	29	39	450
93/04/03	1400	93/04/06	0900	s/m	5.7	4.8	58
93/04/08	0035	93/04/09	1833	1.10	12	45	270
93/04/11	1100	93/04/13	1001	.45	6.4	5.3	69
93/04/15	0335	93/04/17	0713	1.43	18	74	420
93/04/19	1505	93/04/21	2152	1.50	20	67	440
93/06/07	1230	93/06/09	2045	2.39	14	140	510
93/07/05	1700	93/07/07	2100	2.04	12	160	580
93/07/09	0300	93/07/10	2200	1.42	8.0	120	410
93/09/13	1045	93/09/16	0700	2.34	2.3	3.7	37
93/09/20	1435	93/09/22	0900	1.49	2.6	12	78
93/12/24	2100	94/01/04	0500	--	18	.0034	.039

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Otter Creek—Continued							
94/03/20	1200	94/03/25	0800	--	10	9	85
94/04/24	2200	94/04/27	0800	--	4.1	9.9	70
94/05/25	1900	94/05/27	2200	--	2.2	34	130
94/08/01	0200	94/08/02	2100	--	.82	.52	8.2
95/03/11	1100	95/03/13	1100	s/m	64	33	220
95/03/12	0005	96/03/17	1100	s/m	68	16	110
95/04/11	1400	95/04/13	1800	.67	29	2.7	31
95/04/18	0700	95/04/20	0830	1.03	41	9.6	73
95/10/31	2100	95/11/03	0200	1.51	31	17	96
96/01/18	0005	96/01/22	2345	.43	89	6.4	140
96/02/08	0005	96/02/13	2345	s/m	96	5.3	190
96/02/23	0005	96/03/01	2345	s/m	120	19	220
96/04/18	2000	96/04/19	1800	.46	20	4	33
96/04/29	1600	96/05/02	1000	.63	38	1.2	25
96/05/10	0005	96/05/11	2300	.64	28	2.9	30
96/06/07	0200	96/06/09	0100	1.12	67	20	130
96/06/16	2300	96/06/19	1900	3.03	220	45	450
97/02/18	0005	97/02/20	2355	s/m	170	14	180
97/03/10	1500	97/03/11	0700	s/m	18	3	32
97/03/11	1000	97/03/12	0700	s/m	22	3.3	37
97/03/20	0900	97/03/21	0400	s/m	30	7.3	59
97/03/21	0900	97/03/22	0900	s/m	47	9.9	86
97/04/30	1600	97/05/02	0200	1.21	18	1.7	24
97/06/15	2300	97/06/16	2000	.87	3.5	.11	3.3
97/06/20	0400	97/06/23	1800	3.52	170	80	530
97/06/20	0400	97/06/20	2300	.84	4.7	.54	7.2
97/06/20	2300	97/06/23	1800	2.68	170	79	530
Kuenster Creek							
92/11/01	1900	92/11/04	0100	1.38	1.0	1.8	36
92/11/19	1600	92/11/22	0100	2.73	2.4	19	300
92/12/15	0200	92/12/17	0400	s/m	1.7	8.2	220
93/03/05	1100	93/03/06	0400	s/m	1.7	85	440
93/03/07	1400	93/03/08	0700	s/m	4.2	2.70	1,200
93/03/08	1400	93/03/09	0800	s/m	3.4	83	560
93/03/15	2300	93/03/17	0900	s/m	6.5	290	920
93/03/25	1200	93/03/26	0900	s/m	9.7	1,100	3,600

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Kuenster Creek—Continued							
93/03/26	1200	93/03/27	0700	s/m	7.8	430	1,400
93/03/27	1200	93/03/28	0500	s/m	6.6	210	1,190
93/03/28	1300	93/03/29	0600	s/m	4.1	91	540
93/03/30	1200	93/03/31	1900	1.78	14	3,000	6,700
93/05/02	1900	93/05/03	1000	1.63	3.8	340	1,400
93/06/17	1800	93/06/18	2000	.72	3.4	100	730
93/06/28	1600	93/06/29	0600	--	1.4	20	80
93/06/29	2300	93/06/30	2200	1.42	5.8	470	1,600
93/07/17	1000	93/07/17	1900	1.07	2.2	170	470
93/08/14	1715	93/08/16	0500	1.00	4.4	120	455
93/08/18	1100	93/08/19	1100	.88	2.4	36	190
94/03/04	1200	94/03/05	0800	--	6	790	2,000
94/03/05	1200	94/03/06	1100	--	3	85	330
94/06/20	0200	94/06/20	1300	--	.47	6.6	49
94/06/23	0600	94/06/24	2200	--	4.9	130	490
94/07/04	0800	94/07/05	1900	--	2.4	95	390
94/07/14	0100	94/07/15	0300	--	2.9	190	140
94/07/20	0000	94/07/21	0200	--	2.1	55	230
95/04/11	1800	95/04/13	0300	1.53	19	16	130
95/05/09	1900	95/05/11	0300	1.05	28	79	360
95/07/27	1500	95/07/29	0300	1.57	20	15	88
95/08/06	1700	95/08/08	0700	2.48	41	110	450
95/11/01	0700	95/11/03	1100	2.12	27	39	200
96/01/17	1600	96/01/18	2400	.50	26	65	390
96/02/07	0800	96/02/15	0900	s/m	130	38	1,300
96/02/19	0100	96/02/26	2000	s/m	62	36	400
96/05/09	0200	96/05/11	0500	1.65	18	55	410
96/05/28	0500	96/05/29	2100	1.07	18	11	110
96/06/01	1800	96/06/02	2000	.89	9.9	4.7	22
96/06/06	0400	96/06/08	0800	.82	34	61	410
96/06/16	1600	96/06/18	1600	1.62	25	36	270
96/06/29	2100	96/07/01	0500	1.22	10	4.9	34
Rattlesnake Creek							
90/01/16	1700	90/01/18	0800	s/m	9.4	150	1,600
90/03/08	0600	90/03/08	1200	s/m	16	1,300	3,600
90/03/11	0500	90/03/12	0200	s/m	4.1	57	480

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Rattlesnake Creek—Continued							
90/05/09	0115	90/05/10	0100	--	3.2	170	360
90/05/19	0500	90/05/20	2100	--	5.8	83	530
90/06/22	0315	90/06/22	1800	--	3.3	55	180
90/08/24	2000	90/08/25	2300	--	7.9	230	1,600
90/08/26	0900	90/08/27	0400	--	5.6	190	940
91/04/12	1100	91/04/13	1900	1.64	14	98	1,000
91/08/07	2000	91/08/08	2300	2.50	8.3	200	4,600
91/11/01	0045	91/11/02	0330	1.55	5.9	59	650
91/11/29	1100	91/11/30	1700	.80	6.2	29	230
92/02/03	1300	92/02/04	0900	s/m	3.7	69	290
92/02/20	1445	92/02/21	0800	s/m	19	2,800	7,600
92/02/22	1400	92/02/23	1635	s/m	14	1,600	4,400
92/02/24	1500	92/02/25	0900	.24	8.6	420	1,700
92/04/20	1300	92/04/21	0900	.91	4.4	34	520
92/06/16	1000	92/06/17	0300	.66	1.3	.44	14
92/09/07	2230	92/09/08	1800	.90	2.3	4.1	180
92/09/14	1400	92/09/15	1800	.84	2.3	2.9	130
92/11/01	1600	92/11/03	1000	1.25	3.7	3.3	64
92/11/19	2000	92/11/21	2200	2.68	10	68	1,300
92/12/15	0100	92/12/17	0400	.91	7.6	27	510
93/03/03	0300	93/03/05	0600	.27	16	2,100	4,000
93/03/05	1400	93/03/06	0800	s/m	7.7	330	1,700
93/03/06	1500	93/03/07	0800	s/m	4.8	120	1,500
93/03/07	1400	93/03/08	1000	s/m	19	610	4,700
93/03/08	1300	93/03/09	0900	s/m	18	380	3,600
93/03/16	0030	93/03/17	0600	s/m	31	1,400	4,200
93/03/24	1600	93/03/26	1100	s/m	63	4,300	14,000
93/03/26	1101	93/03/27	1000	s/m	31	420	3,000
93/03/27	1200	93/03/28	0800	s/m	26	840	4,300
93/03/28	1300	93/03/29	0900	s/m	15	240	1,700
93/03/30	1300	93/03/31	2000	1.67	43	4,400	14,000
93/05/02	2100	93/05/03	1500	1.64	17	500	2,600
93/06/07	1000	93/06/08	1900	1.53	13	260	1,100
93/06/13	2100	93/06/14	2100	1.01	5.0	29	170
93/06/17	1900	93/06/18	1500	1.25	13	690	2,700
93/06/28	0600	93/06/28	1500	.71	4.7	160	570
93/06/29	2300	93/06/30	1800	1.36	19	1,300	4,400

Appendix. Storm-load data for rural watershed-management evaluation monitoring sites, Wisconsin, water years[1] 1985–98—Continued

[yr, year; mo, month; d, day; h, hour; in., inches; Mft^3, million cubic feet; lb, pounds; s/m, snowmelt; --, no data]

Start of storm		End of storm				Loads	
Date (yr/mo/d)	Time (24 h)	Date (yr/mo/d)	Time (24 h)	Precipitation (in.)	Streamflow volume (Mft^3)	Suspended-solids load (tons)	Total-phosphorus load (lb)
Rattlesnake Creek—Continued							
93/07/05	1200	93/07/06	1500	1.69	19	470	3,000
93/07/08	2330	93/07/09	2000	2.35	71	8,700	25,000
93/07/10	1600	93/07/12	0400	2.39	78	8,500	24,000
93/07/17	0900	93/07/18	0200	0.97	12	480	1,700
93/08/14	1700	93/08/15	0545	.97	6.5	130	590
93/08/15	0900	93/08/16	0100	.74	10	150	810
93/08/18	1300	93/08/19	0600	1.00	11	220	1,200
94/02/18	1600	94/02/21	0800	--	160	4200	15000
94/03/04	1300	94/03/05	0900	--	27	1900	6300
94/03/05	1100	94/03/06	0900	--	13	290	1600
94/06/20	0100	94/06/20	1900	--	2.7	20	83
94/06/23	0700	94/06/24	2300	--	16	520	2200
94/07/04	0700	94/07/05	1800	--	7.8	170	870
94/07/14	0200	94/07/14	2000	--	6.4	320	280
94/07/20	0015	94/07/20	1700	--	5.5	140	730

[1]Water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends. Thus, the year ending October 1, 1997, and ending September 30, 1998, is called “water year 1998.”